1974 25 1999

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Acknowledgement of Sponsors

The Center gratefully acknowledges the support of its many government and industrial sponsors over the past 25 years. A list of these organizations appears on the inside back cover.

A Look Back

CCM Executive Director since 1996, Karl V. Steiner joined the Center in 1984 as a visiting researcher under a fellowship by the German Carl Duisberg Society. Prior to his current position, he served in a succession of Center managerial positions, including Assistant, Associate, and Interim Director. Steiner has contributed more than 50 technical publications and given numerous research seminars and invited presentations at international conferences. From 1996 to 1998, he served as the founding Executive Director of the Fraunhofer Center–Delaware, one of the State's three initial Advanced Technology Centers.

A quarter century is a remarkable milestone for any organization. Back in 1974, the Center for Composite Materials was one of the first academic centers with a focus on these manmade materials, and the Center's long-term success emphasizes the vision of its founders and its strong leadership over the past 25 years. The Center has experienced many internal and external challenges and changes during its history but has thrived, taking advantage of the inherent properties of composites and their wide-ranging opportunities. This commemorative volume looks back at some of the milestones in the Center's history.

My own initial exposure to composites occurred when I joined CCM in 1984 as a visiting research assistant integrating robotics with ultrasonic nondestructive testing. At that time, the Center had already established a strong industrial consortium. In the coming two years, CCM would receive major national and international recognition through the awards of both a National Science Foundation Engineering Research Center and a Center of Excellence by the Army Research Office. Both of these programs helped move CCM into manufacturing science, a new and exciting area that would combine the Center's academic expertise in process modeling and simulation with industrial needs for robust, reliable, and cost-effective composites manufacturing processes. Today, some 15 years later, the initial concepts outlined in the proposals to NSF and ARO have become the cornerstone of the Center's success in research, technology transfer, and education.

Over this past quarter century, the Center has invested over $65 million in composites research. To date, we have helped educate well over 1000 students, with 130 PhDs and 160 master's degrees awarded to students affiliated with the Center. CCM has become an internationally recognized Center of Excellence, hosting visiting faculty, researchers, and students from over 20 countries.

I hope you enjoy this commemorative volume and join us in our look back at the first quarter century of the Center for Composite Materials. The best is yet to come.

The World in 1974

- The moon's last human visitors are back on earth, following the termination of the Apollo program two years ago after six manned trips to the moon.
- ARPANet, the predecessor to the modern Internet, is five years old.
- The gasoline shortage reaches its worst point, with 6-mile-long lines reported at stations in the New York area and many stations closed down for lack of supplies.
- 3M develops the Post-it note.
- The UPC is introduced by the supermarket industry.
- Hank Aaron hits his 715th home run, breaking Babe Ruth's 39-year-old record.

Nixon resigns (1974)

- Inflation is cited as the nation's worst problem, surpassing the oil crisis and environmental concerns.
- Nixon becomes the first U.S. President to resign, and Ford becomes the first American to become President without being elected.
- Pioneer II nears Jupiter and sends photos back to earth.
- The Sears Tower in Chicago, the tallest building in the world, is completed.
- Hewlett Packard introduces the first programmable pocket calculator.

last lunar landing (1972)

Arab oil crisis (1974)

The Dow Jones Industrial Average reaches 673 in October 1974.

The median family income in the United States is $15,000.

"The Godfather Part II" wins the Academy Award for Best Motion Picture.

"I Honestly Love You," by Olivia Newton-John, wins the Grammy Award for Best Record.

UD enrollment totals 14,749.

The Center for Composite Materials is founded at the University of Delaware by Profs. Jack R. Vinson and Tsu-Wei Chou.

Jack R. Vinson

Center Director from 1974–1978, Jack R. Vinson is now H. Fletcher Brown Professor of Mechanical and Aerospace Engineering, with an additional appointment to the College of Marine Studies. He is a Fellow of both the American Society of Mechanical Engineers and the American Institute of Aeronautics and Astronautics. He is the author of several books and more than 200 papers. Most of his research since 1956 has involved structures composed of composite materials. Vinson is currently President of the American Society for Composites (ASC) and a member of the *Journal of Composite Materials* Editorial Board.

In 1956, my first introduction to composite materials, as an engineer with General Electric, was to perform a structural analysis of a spherical shell data capsule, made of chopped glass cloth and melamine resin, to be ejected from a re-entry vehicle, survive re-entry and subsequent water entry at terminal velocity. Later, my Ph.D. dissertation at the University of Pennsylvania in 1961 dealt with new techniques of solution for composite material plates.

I came to the University of Delaware in 1964 in Civil Engineering and in 1965 became the Chairman of Mechanical Engineering (which in 1966 became Mechanical and Aerospace Engineering). My research focused on composite materials under NSF and AFOSR sponsorship.

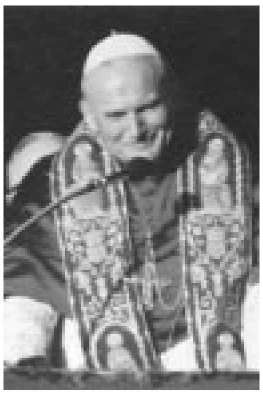
By 1969, I had formulated and taught a course in composite materials, which is believed to be the third course in composite materials ever taught (the first was by Dietz at MIT in the 1950s, the second by Charles W. Bert at Oklahoma in 1968).

At the same time, Tsu-Wei Chou joined our faculty. He and I have taught a course in composite materials each year since that time. Chou was a major addition, bringing more of the materials science aspects to the composite materials research at the University.

By 1973-74, the research productivity, the sponsored research, and the number of graduate students conducting composites research were sufficiently impressive that an outward and visible sign of this effort was in order. As Chairman of Mechanical and Aerospace Engineering, I composed a document in late 1973 to the University administration that resulted in the formation of the Center for Composite Materials. It was intended that "the whole [would] be greater than the sum of the parts through increased cooperation and the ability to obtain additional resource allocation through the formation of the Center."

During its 25 years, the Center has become a focal point for major support by government and industry, and it has become the mecca that we envisioned for researchers around the world to come and collaborate.

USA bicentennial celebration (1976)

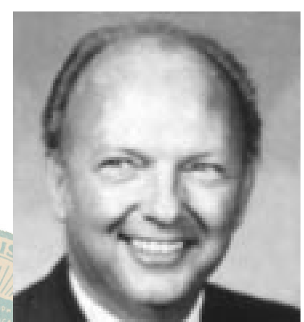


Pope John Paul II elected (1978)

The University of Delaware Center for Composite Materials will consist of researchers, students, support personnel, and the supporting resources to effect progress in the development of composite materials and their structural utilization. Those contributing to the Center will form a research team that can and will make rapid and significant advances in analytical and experimental research and development in this rapidly growing area.

These words were the core of a proposal written by Prof. Jack R. Vinson and submitted to the University Provost in February 1974 to form a Center for Composite Materials at the University of Delaware. The proposal was approved, and the Center was initiated in August 1974, with Vinson as Director and Prof. Tsu-Wei Chou as a key researcher. The following year, R. Byron Pipes joined the mechanical engineering faculty at UD. An experimentalist, Pipes provided the "third leg of the capability stool," complementing the analytical acumen in structural mechanics and materials science provided by Vinson and Chou, respectively.

Pipes brought to the Center more than just expertise in experimental mechanics. He also had the vision to shift the Center's funding focus from federal to industrial sources and its research emphasis from structural mechanics and materials science to manufacturing and processing.



Soliciting major support from industry for an academic research center was a novel concept at the time. In the early 1970s, the primary support for university research centers had come from the federal government. A number of Interdisciplinary Laboratories (IDLs) in the materials field had been established in 1960 by the Department of Defense (DOD) Advanced Research Projects Agency (ARPA). By 1972—after passage of the Mansfield Act, requiring direct, near-term application of defense-sponsored research and development—ARPA

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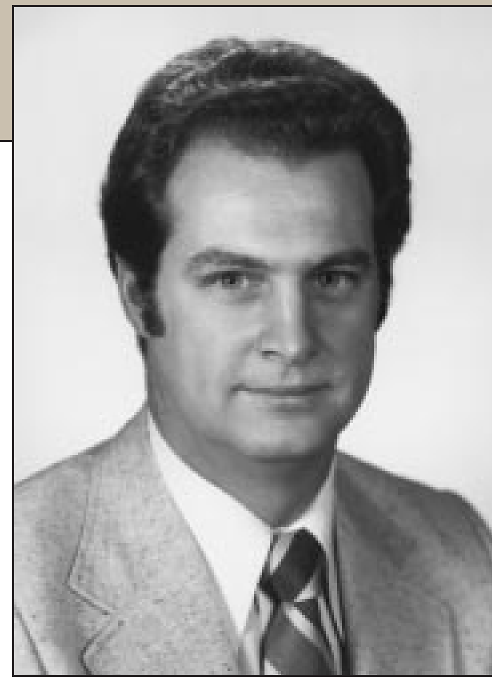
R. Byron Pipes



CCM Director from 1978–1985, R. Byron Pipes is credited with initiating the Industry-University Consortium in 1978, pioneering a new way for academia to interact with the private sector. Under his leadership in 1985, CCM was named one of the initial six NSF Engineering Research Centers. Elected to the National Academy of Engineering in 1987, Pipes has co-authored four books and edited a book series. After his term as CCM Director, Pipes served as Dean of the College of Engineering and University Provost at Delaware and as President of Rensselaer Polytechnic Institute. He has also served on numerous state and national panels and committees.

CCM's industrial consortium, *Application of Composite Materials to Industrial Products*, began with a pilot program with the Rogers Corporation in 1977 aimed at transitioning phenolic molding compounds from asbestos to glass fiber reinforcement. This pilot program provided the vehicle to establish model working relationships between academia and industry, build credibility for CCM with the automotive industry, and discover the barrier issues that hindered the adoption of these new materials systems beyond the aerospace industry. The Rogers program continued for ten years and successfully transformed the company's technology and materials systems.

The Rogers program provided the platform needed for scale-up and launch of the industrial consortium in 1978. The consortium then grew rapidly from eight sponsors to almost 40 representing global corporations in Europe, Asia, and the United States. What began as a non-aerospace consortium ultimately embraced both commercial and defense aerospace organizations, and its members included materials suppliers and end users from a range of industries.

From 1978 to 1984, the consortium program rose from $200,000 to over $1.5 million per year, while participation of faculty and students grew exponentially. The *Delaware Composites Design Encyclopedia* was published, along with a growing list of research reports. Annual research symposia and workshops were held to facilitate technology transfer to our industrial and government sponsors.

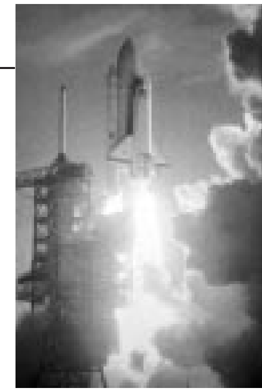
In 1984, CCM competed successfully to become one of the first six NSF Engineering Research Centers. Manufacturing science was chosen as the expanded focus of the Center, since this technology need was viewed as the primary barrier to the economical application of composite materials. This new thrust required that CCM significantly broaden its research programs and expand its facilities. A gift of $1 million from ICI Americas in 1984 leveraged $2.5 million in State support for construction of the 34,000-square-foot Composites Manufacturing Science Laboratory, which was opened in 1988. CCM's annual expenditures reached almost $4 million in 1989—an extraordinary record of growth since its inception in 1974.

Reagan and Bush elected (1980)

Mt. St. Helens erupts (1980)

transferred the IDLs to the National Science Foundation (NSF) and discontinued its composite materials center at Washington University–St. Louis. Concurrently, NASA began to make significant investments in composite materials technology for civil aviation and space applications. Numerous university research programs were initiated in the early 1970s.

It was in this environment that CCM was founded, and it soon became clear that the path to its success lay with the American automotive, chemical, and manufacturing industrial sectors. These consumer product industries had already begun development of composites technology, but there was a clear need for both research and education of the workforce in these industries by American academia. In fact, this was a period when the non-aerospace sector felt that its needs were not being met by university programs driven by defense and aerospace.



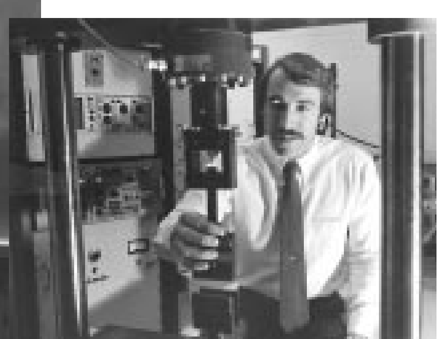
first space shuttle flight (1981)

Charles and Diana wed (1981)

Thus, the CCM initiative to develop an industrially sponsored research and education program in composite materials was warmly embraced by the corporate sector, and the consortium, *Application of Composite Materials to Industrial Products*, was launched in 1978.

At the same time, then-Dean of Engineering Irwin G. Greenfield decided to split the duties of Chairman and Director, resulting in Vinson remaining as Chair of Mechanical and Aerospace Engineering (MAE) and Pipes becoming Center Director. This paved the way for CCM to become a College-wide center within two years, opening the door for interdisciplinary activities with other departments and programs, including chemical engineering, civil engineering, metallurgy, and materials science.

The consortium began to grow rapidly, with a research program that was at once broad as well as focused, encompassing the significant



Disney opens Epcot Center (1982)

first untethered spacewalk (1984)

technologies that limited the exploitation of composites in industrial applications. Basic to the Center's approach was the recognition that technological evolution requires a comprehensive program under which several research areas are developed simultaneously. Consistent with that philosophy, the Center's research program was organized into six primary areas: mathematical materials modeling, computer-aided design, processing science and rheology, microstructural analysis, durability, and nondestructive evaluation.

Recognizing also that the success of the consortium hinged on providing salient information to industry as it evolved, Center leaders incorporated into the program a number of vehicles for the transfer of new and established technology, including a composites design encyclopedia, composites software and users' guides, annual workshops and symposia for industrial personnel, and a series of technical reports released to sponsors immediately upon completion. The technical report series was initiated in 1979, and more than 30 reports were issued during the first two years of the program.

By 1980, 13 companies comprising the three major segments of the composites industry—raw material producers, intermediate material suppliers, and end users—were represented

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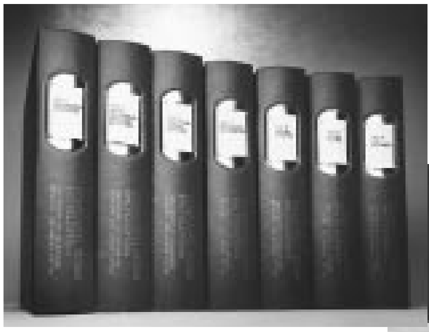


The World in 1984

Olympic Games in Los Angeles (1984)

Chrysler introduces the minivan (1984)

- ***Two American astronauts become the first "human satellites" when they float free of space shuttle Challenger. Two years later, Challenger will explode, killing the entire crew including school teacher Christa McAuliffe.***
- ***President Reagan signs cultural and political agreements with China.***
- ***The Soviets boycott the Summer Olympics in Los Angeles.***
- ***The price of the average home in American surpasses the $100,000 mark.***
- ***Geraldine Ferraro becomes the first female VP candidate in the U.S.***
- ***Pontiac introduces the Fiero, the first car with integrated composite body panels.***
- ***Chrysler introduces the minivan, revitalizing the U.S. auto industry.***
- ***Apple introduces the Macintosh, a "user-friendly" personal computer with superior graphics capabilities.***

Apple introduces Macintosh (1984)

- ***The fountain pen is 100 years old.***

The Dow Jones Industrial Average reaches 1225 in October 1984.

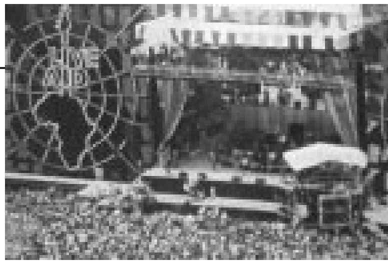
The median family income in the United States is $31,000.

"Amadeus" wins the Academy Award for Best Motion Picture.

"What's Love Got To Do with It," by Tina Turner, wins the Grammy Award for Best Record.

University of Delaware enrollment totals 18,082.

The Center for Composite Materials establishes research in composites manufacturing science.



Live Aid concert in Philadelphia (1985)

Gorbachev new Soviet leader (1985)

in the consortium. A unique forum had been created in which sponsor personnel interacted closely with students and faculty. The sponsored research served not only to advance composite materials technology but also to train new scientists and engineers in the design and processing of composites. The budget had almost doubled from the Center's first-year expenditures of $200,000 to $390,000 in 1980–81. In 1983, CCM moved into the Robert L. Spencer Laboratory, the newly completed engineering building housing MAE. At this point in its history, the Center had become the largest group of non-industrial researchers in the U.S. involved in the study of composite materials.

Rapid growth continued

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Dick J. Wilkins

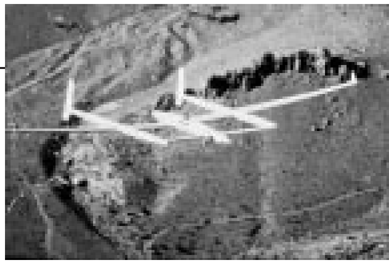
Center Director from 1986–1990, Dick J. Wilkins joined CCM after 17 years with the General Dynamics Corporation in Ft. Worth, Texas. Following his term as Center Director, he served as Director of the Institute for Applied Composites Technology and President of the Delaware Technology Park. Now Professor of Mechanical Engineering, Wilkins has taken a leadership role in revamping the ME undergraduate curriculum for the 21st century and is serving as Associate Dean of the College of Engineering. He is a Fellow of the American Society for Composites.

When I joined CCM fresh from industry in 1986, the National Science Foundation (NSF) Engineering Research Center (ERC) was beginning at Delaware. Although I was new to academia, the ERC concept was not new to me. I had represented the aerospace industry at the NSF site visit to UD during the ERC competition, and my interest in engineering education was strong because one of my responsibilities at General Dynamics was to chair the Engineering Education Advisory Committee. The committee was chartered to suggest ways of teaching engineering, doing relevant university research, and preventing engineering obsolescence. I believed strongly that the ERC concept was a means to all of these ends and welcomed the opportunity to become directly involved.

When the ERC was awarded to Delaware in 1985, the Center enjoyed the membership of 35 international companies in the composites field. Of major significance to our research was that the sponsors covered a broad range of interests, from the supplier side of the business to both the aerospace and automotive branches of the user community. Our industrial partners agreed with us that the barriers in composites technology must be expanded to include manufacturing issues. This strategy was the key to the NSF award of the ERC for Composites Manufacturing Science and Engineering. The idea was to move beyond traditional engineering pursuits into manufacturing by adopting an interdisciplinary approach and taking a systems-level viewpoint.

Our next major partner in research was the U.S. Army Research Office, which established the Center of Excellence for Manufacturing Science, Reliability, and Maintainability Technology at UD in 1986. This effort built very logically on our design, analysis, testing, and manufacturing expertise to address the final component of the overall engineering problem—i.e., in-service reliability and maintenance.

Soon after the inauguration of the ERC, we started the Composites Manufacturing Science Lab. In 1988, this unique building became the home of CCM's researchers, along with all the near-future processes considered to be key to the future of composites manufacturing.



Voyager circles the globe nonstop (1986)

Shuttle Challenger explodes (1986)

throughout the first half of the 1980s, with 1984–85 a banner year in terms of both growth and achievement. In September 1984, the Center celebrated its tenth anniversary with a week-long international symposium. In May 1985, based on CCM's nationally recognized composites research and education programs, NSF designated UD as an Engineering Research Center (ERC), with Pipes as Principal Investigator. The five-year, $7.5-million program was one of six initial ERCs, established to "enhance the future competitiveness of U.S. industry in international markets while contributing to education and research," according to NSF Director Erich Bloch.

Pipes served as Director of the NSF Center for Composites Manufacturing Science and Engineering until he was named Dean of UD's College of Engineering in July 1985. By then, the Center's annual budget was close to $2 million, and the consortium had grown to include 35 industrial sponsors. Center personnel included close to 20 faculty, 10 professional staff, almost 30 graduate students, and an equal number of undergraduates.

During the

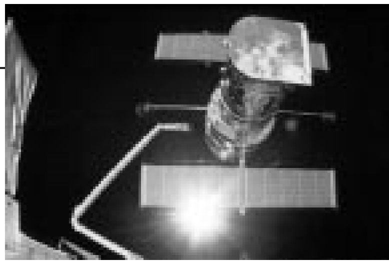
national search for a replacement for Pipes, Associate Director Roy L. McCullough served as Interim Director. McCullough had joined the University in 1971 as Professor of Chemical Engineering and had been an active Center-affiliated faculty member since its early days.

1986 began with Dick J. Wilkins, who had been with General Dynamics for 17 years, being named CCM Director and bringing an industrial perspective to the Center. By mid-1986, CCM had received another major national accolade—being designated a U.S. Army Center of Excellence with a grant from the Army Research Office (ARO) of $5.3 million over five years. The ARO program was led by Chou and McCullough. Between 1985 and 1990, Center expenditures totalled nearly $20 million, with funding from industry, NSF, DOD, NASA, and the State of Delaware.

In line with the heightened emphasis on manufacturing science under the NSF and ARO programs, plans had been launched in 1985 for the Composites Manufacturing Science Laboratory (CMSL) at UD. With funding from the State and ICI Americas, the CMSL was dedicated in May 1988. The 34,000-square-foot facility housed equipment for a range of manufacturing

Stars 'n' Stripes wins Americas Cup (1987)

B-2 stealth bomber unveiled (1988)



Hubble space telescope launched (1990)

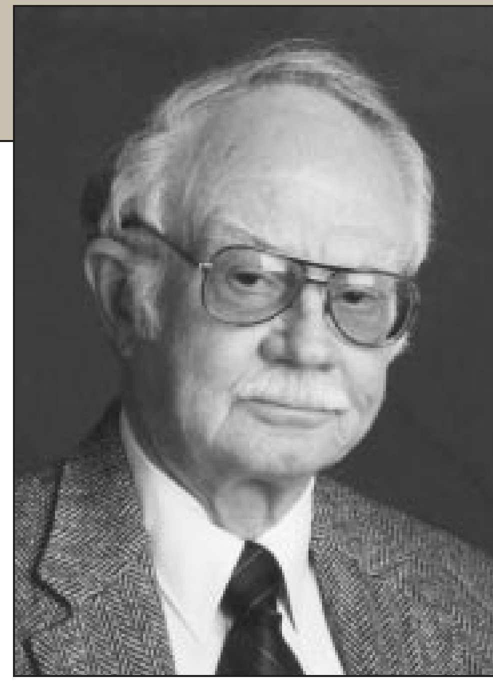
Berlin Wall crumbles (1989)

processes, including sheet forming, liquid molding, injection molding, filament winding, tape consolidation, autoclave molding, and textile preforming. Research in the "traditional" thrust areas continued under the industrial consortium, while the NSF program focused primarily on manufacturing science, and the Army program was targeted at thick-section processing, reliability, and maintainability.

The early 1990s witnessed a change in Directorship and the beginning of a new era in funding and research direction. McCullough once again demonstrated his leadership capabilities, taking over as Director when Dick Wilkins accepted positions as President of the fledgling Delaware Technology Park and Director of the Institute for Applied Composites Technology (IACT).

Major global changes at this time necessitated a serious reassessment of CCM's strategy for interacting with industry and government. The Berlin Wall had fallen, and the USSR, formerly a major world power, had fragmented into 15 independent republics. With headlines reporting a worldwide *continued on page 18*

Roy L. McCullough



In addition to serving as Center Director from 1990–94, Roy L. McCullough was also Associate Director for several years and twice served as Interim Director during transition periods at the Center. He joined the UD faculty in 1971 after working in industry for ten years, first for Monsanto and later for Boeing. McCullough was Co-principal Investigator of the Center's ARO/URI program in manufacturing science for more than a decade. Currently Professor of Chemical Engineering, McCullough has advised close to 100 students during the past quarter century, including five who now hold faculty positions at various universities.

I am particularly proud of the role the Center has played in impacting educational programs. The Center offers an interdisciplinary research and teaching environment to faculty, postdoctoral fellows, and graduate and undergraduate students from all of the engineering departments as well as chemistry, physics, and business. In this eclectic setting, the students sharpen their problem-solving abilities, learn the value of teamwork, and acquire superb communication skills. My previous ten-year experience in industry convinced me that these attributes are vital to a successful career. Upon joining the faculty, I was determined to provide opportunities to our students to acquire these complementary skills.

Many of the Center's alumni were co-advised by faculty from two or more departments or by UD faculty and adjunct faculty from industry and federal laboratories. As a pioneering center in composite materials, CCM has had an important educational impact by supplying faculty to other universities. More than 30 Center alumni are now teaching and conducting research at colleges and universities throughout the world.

The Center's influence goes beyond those students who have had direct interactions. CCM's research has been systematically incorporated into existing courses and prompted the development of new ones. Interactive Web-based instructional materials and CD-ROMs have been developed and provided to other universities to supplement their course material.

CCM's significant educational contributions have been recognized at the national level. A 1988 poll by the Suppliers of Advanced Composite Materials Association rated the University of Delaware, through CCM, as the top university in providing qualified personnel. Recently, UD received one of 10 prestigious awards from NSF for the exemplary integration of research and education. The Center's contributions to this achievement are well recognized.

As I look back over the past quarter of a century, it is clear that our students have been our most important products. Their continuing respect, loyalty, and commitment to the traditions of the Center will have a lasting impact.

The Medal of Excellence

The Medal of Excellence in Composite Materials was established in 1984 in conjunction with the Decennial Celebration of the Center for Composite Materials. It was created to honor those who have achieved outstanding leadership in the composites field and who have maintained and demonstrated scholarly endeavor, invention, and/or economic enterprise over a sustained period of time.

Designed by internationally recognized Wilmington sculptor Charles Parks, the medal is a three-inch-diameter bronze casting that bears the likenesses of the four initial medal winners: Dr. Zvi Hashin, Dr. Tsuyoshi Hayashi, Dr. Anthony Kelly, and Dr. Stephen W. Tsai.

Dr. Zvi Hashin
1984

Dr. Anthony Kelly
1984

Dr. B. Walter Rosen
1985

Dr. Alan Lovelace
1986

Dr. Akio Shindo
1987

Mr. Roger Bacon
1987

Dr. Richard M. Christensen
1989

Dr. Derek Hull
1990

Ms. Stephanie Kwolek
1992

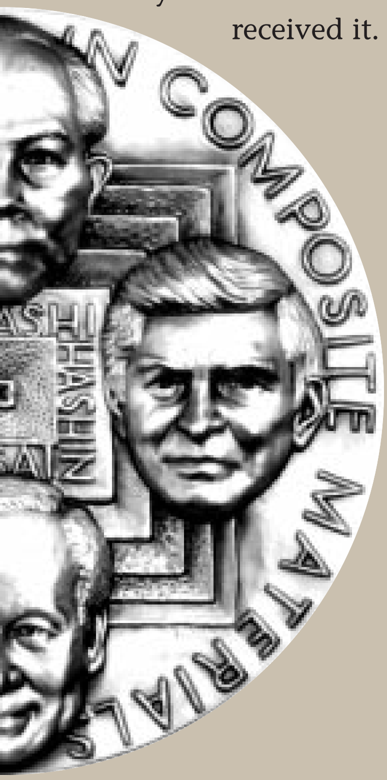
Dr. Georg Menges
1993

Dr. R. Byron Pipes
1994

in Composite Materials

The seal of the University of Delaware with a blank scroll beneath it, to be inscribed with the name of the recipient, appears on the reverse side of the medal.

The design and striking of the medal were supported by generous grants from the DuPont Company, Hercules Inc., ICI Americas Inc., and Toray Industries (America), Inc. The prestige of the Medal of Excellence in Composite Materials, manifested in the list of internationally honored award winners pictured here, has grown over the years commensurate with the reputations of those who have received it.



Dr. Tsuyoshi Hayashi
1984

Dr. Stephen W. Tsai
1984

Gen. Bernard A. Shriever
1986

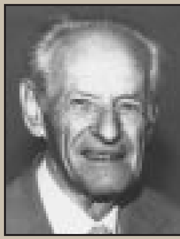
Mr. George P. Peterson
1986

Dr. William Watt
1987

Dr. Karl M. Prewo
1988

Dr. Roger Naslain
1991

Dr. Herbert Blades
1992



Dr. Paul W. Morgan
1992

Dr. H. Thomas Hahn
1996

Dr. C. T. Sun
1997

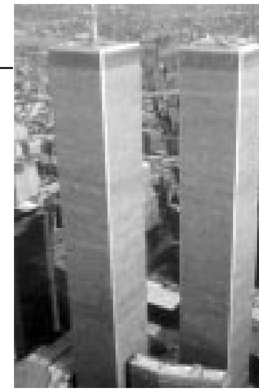
Dr. George S. Springer
1999

The Persian Gulf War (1991)

Clinton and Gore elected (1992)

recession, a decline in the sales of commercial aircraft, reductions in defense procurement, and restructuring of companies, the Center regrouped. Although the NSF funding was discontinued and consortium membership was down, the Army program was renewed for another five years, and new opportunities were opening up. In 1992, the Center, together with IACT, won two DARPA awards to develop rapid manufacturing technologies, one for polymer-matrix composites (RAPTECH–PMC), the other for ceramic-matrix composites (RAPTECH–CMC). With the RAPTECH programs, the Center established a new model for working with the private sector—i.e., industry as partner rather than patron. Eventually, the RAPTECH program would result in transfer of the automated thermoplastic tow-placement process to industry for commercialization.

Through RAPTECH and other programs, CCM had demonstrated



World Trade Center bombed (1993)

Mideast peace accord reached (1993)

the capability to catalyze and nurture major multidisciplinary programs using a team approach, and this facilitating role took on new importance in the mid-1990s.

In 1994, CCM was awarded four substantial grants in partnership with other academic institutions and/or industry through DARPA's Technology Reinvestment Project (TRP): a follow-on RAPTECH program focused on affordability (RAPTECH-ACM); the Bridge Infrastructure Renewal (BIR) program; a manufacturing education and training program in composite materials for DOD and industry (awarded jointly with Michigan State University); and the Affordable Composites for Propulsion (ACP) program. Initiated in 1993, the TRP provided funds for projects that would develop dual-use technologies. Despite fierce competition—close to 3,000 proposals were submitted to the $500-million *continued on page 21*

The World in 1994

English Channel tunnel opens (1994)

Los Angeles earthquake (1994)

- ***The Internet as we know it—with the capability for users to link words, pictures, and other files to each other through mouse clicks—is three years old.***
- ***The first NATO air attack over Bosnia is launched.***
- ***The 50th anniversary of D-Day is celebrated.***
- ***The U.S. Food and Drug Administration approves the sale of the first genetically engineered tomato.***
- ***Defense contractors Lockheed and Martin Marietta announce their merger.***
- ***The Brazilian national soccer team wins its fourth World Cup title in Pasadena, California, with 2 billion people throughout the world watching the final match.***
- ***The radio and the time clock are 100 years old.***
- ***Former U.S. President Richard M. Nixon dies.***
- ***Nelson Mandela, who spent 27 years in jail as a prisoner of the apartheid regime, is sworn in as South Africa's first black head of state.***
- ***England is connected to the European mainland when the 31-mile Channel tunnel to France is completed.***

Nelson Mandela becomes South Africa's first black president (1994)

The Dow Jones Industrial Average reaches 3936 in October 1994.

The median family income in the United States is $47,000.

"Forrest Gump" wins the Academy Award for Best Motion Picture.

"All I Wanna Do," by Sheryl Crow, wins the Grammy Award for Best Record.

University of Delaware enrollment totals 21,585.

The Center for Composite Materials pioneers intelligent process control for composites.

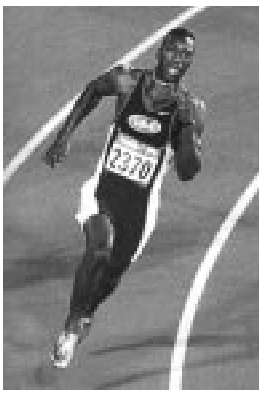
O. J. Simpson found "not guilty" (1995)

Kobe (Japan) earthquake (1995)

program—CCM competed successfully for these funds, winning four out of eight proposals submitted, and entered a new era of partnerships and collaboration.

One of the winning projects, the BIR program, also opened up a new era in CCM's technical history. With the deterioration of aging infrastructure becoming a major national problem, Center researchers teamed with the Department of Civil & Environmental Engineering (CEE), industry, and the Delaware Department of Transportation (DelDOT) to explore the application of composites—previously used primarily for aerospace, automotive, and sporting goods applications—to civil structures such as bridge decks and marine pilings for functions

terrorism strikes Oklahoma City (1995)



Olympic Games in Atlanta (1996)

ranging from repair and rehabilitation to retrofitting for seismic resistance. Over the next several years, the team, led by CCM Associate Director John W. Gillespie Jr., conducted several successful projects, culminating in 1998 with the construction and installation of one of the nation's first all-composite bridge decks on a state-owned road. The project would go on to win the Delaware Project of the Year award from the American Society of Civil Engineers.

During this period, the Center underwent additional changes in leadership. McCullough stepped down from the Directorship to devote more time to teaching, and Assistant Director Karl V. Steiner served as Interim Director. Following a nationwide search, Richard P. Wool, Professor of Chemical Engineering at the University of Illinois–Urbana Champaign, was named CCM Director in 1995.

The Center continued to forge new partnerships. In 1995, CCM became a core member of the ARO-funded Tuskegee University Research Consortium, which is investigating intelligent resin transfer molding for integral armor applications. The following year, CCM was selected by the

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Richard P. Wool

Center Director from 1995–96, Richard Wool joined the University of Delaware after 18 years as a faculty member at the University of Illinois. Wool is the author of a book and more than 100 papers. He is now Professor of Chemical Engineering, President of Cara Plastics, Inc., and leader of the ACRES (Affordable Composites from Renewable Sources) research group at the University of Delaware. Under this program, Wool and his students, many of whom have won awards and prestigious fellowships, are investigating the use of plant-based oils as composite resins and the use of natural fibers as reinforcement for these materials.

While composite materials continue to be among the critical technologies identified by the U.S. government as essential to maintenance of our national competitive position in a global marketplace, affordability and impact on the environment have become increasingly important issues associated with advanced composite materials.

We started our research in the ACRES program, which currently focuses on making high-performance composites from the common soybean, when I heard major companies like DuPont and Monsanto echoing my own sentiments about global sustainability. As early as 1938, Henry Ford was making an auto body using a plastic matrix derived from soybean products. Formulated with soy proteins, these materials were found to be highly resistant to impact. So using natural resources to make a "high-tech" product is really an old idea that's just become new again in response to pressing environmental concerns.

We are now genetically engineering these natural materials into new chemical systems that can be manufactured into components for farm machinery, cars, and infrastructure applications through this multidisciplinary, international effort. At the same time, we are giving equal attention to affordability, which is essential if these novel resin systems are to be embraced by industry and make their way into the commercial market.

In addition to the work being conducted under the ACRES program, CCM is also contributing to an effort led by the Army Research Laboratory to develop environmentally friendly repair and remanufacturing processes for composites. Funded by SERDP (Strategic Environmental Research and Development Program), this project is simultaneously addressing several manufacturing and repair techniques with the potential to reduce fabrication scrap rates, mitigate the emission of hazardous chemicals during processing, and eliminate shelf-life issues through the introduction of new resin systems.

I think these "green" programs are just the beginning of a new focus for CCM that will take us into the 21st century cognizant of the need to maintain quality and reduce costs while also protecting our increasingly fragile environment.

Sojourner explores Mars (1997)

Hale Bopp comet nears Earth (1997)

Army Research Laboratory (ARL), which had recently moved to Aberdeen, Md., as one of three Materials Centers of Excellence through the Composite Materials Research (CMR) Collaborative Program. Led by Gillespie, the CMR program established a new paradigm for university/government teaming. Comprising joint research, scientific exchange, and facilities sharing, the program focuses on developing materials by design for the "Army After Next."

With rapid growth in contract research, the decision was made to divide the leadership of the Center into administrative and technical segments. In 1996, Steiner became Executive Director, and Gillespie Technical Director.

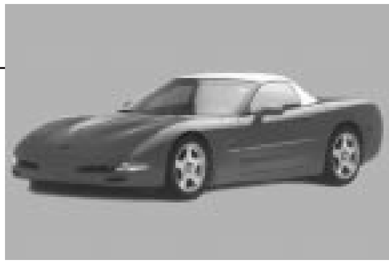
1997 marked the initiation of yet another major program at the Center, when the Office of Naval Research awarded funds to CCM, the Department of Mechanical Engineering (ME), and industry to establish the Advanced Materials Intelligent Processing Center (AMIPC) at UD. Led by Steiner and ME Prof. Suresh Advani, the AMIPC focuses

on the integration of simulation tools with on-line sensing and control for cost-effective automated RTM processing.

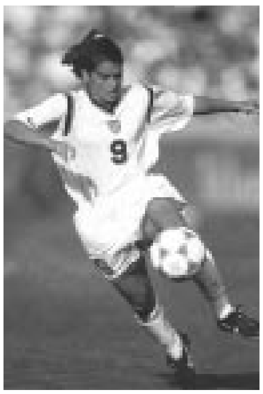
The latter half of the 1990s also witnessed the initiation of a new research direction for the Center. The environmental movement was gaining steam, and awareness of the need to address "green" issues associated with composites was growing. After his term as Director, Wool began to devote full attention to his research—Affordable Composites from Renewable Sources (ACRES). For the past four years, the ACRES team has been investigating the use of plant-based oils, particularly soy oil, for the synthesis of composite resins, as well as the use of natural fibers for reinforcement. In another "green composites" effort, the Strategic Environmental Research and Development Program (SERDP) in 1998 funded a team comprising CCM, ARL, and industry to investigate nonpolluting composites repair and remanufacturing for military applications.

John Glenn returns to space at 77 (1998)

ICE train crashes in Germany (1998)



fifth-generation composite Corvette (1999)



U.S. women win World Cup (1999)

Today, there are single or multiple researchers in a number of universities in the country without any type of organization or common endeavor. The time is now ripe for the formation of a strong center of composite materials that will contribute to the educational program, contribute to the research needed in this area, and contribute to the dissemination of information and service to the general industrial, governmental, and institutional community that will increasingly use these exciting materials systems.

The 1974 vision of the Center's founders has been realized. CCM has contributed to the education of hundreds of students, to the research needs of over 100 companies worldwide, and to the dissemination of research and service to a community that continues to find new challenges and opportunities uses for these exciting manmade materials—composites.

A Look Ahead

CCM Technical Director since 1996, John W. Gillespie Jr. is also professor of materials science and civil engineering. He is the author/co-author of more than 350 publications, series editor of the *Delaware Composites Design Encyclopedia*, editor of the *Journal of Thermoplastic Composite Materials*, and co-inventor of four patents. He is a member of the National Research Council (NRC) Board on Manufacturing and Engineering Design. Gillespie is UD PI of the ARL Composite Materials Research Collaborative Program and, with Army co-investigators, winner of the 1998 Paul A. Siple Memorial Award for his work in developing co-injection resin transfer molding and diffusion-enhanced adhesion.

"The Future is Composites" was the CCM slogan of the 1980s. That future is now.

The need for lightweight materials in the 1960s and 70s—complemented by novel ideas about how to meet that need—drove the initial research enterprise in composites, resulting in new materials, processes, and characterization and design methods. Composites science and technology matured throughout the 80s, and existing materials have been optimized and have found increased use in various industries. In one sense, the future has been realized as basic and applied research has been successfully transitioned, providing a multitude of materials and processes for a variety of applications.

The need for affordable composites will continue to drive research in innovative processing, automation, sensing, and on-line control, as cost remains one of the primary barriers to widespread use in high-performance DOD and commercial systems. Lower-cost materials and processes are needed for high-volume markets such as infrastructure, transportation, and marine.

Current research is also driven by the need for revolutionary new materials to be used in future applications for which current systems are inadequate. Army After Next requirements will be a major driving force in the development of new materials and processes for highly mobile armored vehicles and soldier protection systems. These applications demand multifunctional hybrid systems comprising multiple materials that combine physically to yield enhanced behavior. Interphase science will be increasingly critical in the optimization and design of these materials.

New composites applications must be affordable and last longer to reduce both acquisition and maintenance costs. Research in long-term durability will become increasingly important, as will the development of smart structures with in-situ sensing capabilities to provide feedback on residual life. With continued increases in high-volume applications of composites, research into environmental issues will also be increasingly important.

"Composites for life" is our slogan for the new millennium. The brief history highlighted in this commemorative volume shows that we are well-poised to meet the challenges of the Year 2000 and beyond in collaboration with our industrial and government partners.

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