

IN THIS ISSUE...

Fuel Cell / Gas Turbine Hybrid Power Systems for Distributed Generation

4

Taking Stock of the Gas Turbine Industry...The Wall Street Perspective

9

E-Committee...a model

13

ASME TURBO EXPO 2000 - Wrap-Up

16

TE '01 Call for Papers

20

Introducing the New IGTI Technical Committee Chairs

22

In Memorium...

Frank Carta and Jim Peters

26, 28

The "Big Easy" to Host ASME TURBO EXPO '01

TE'01, IJPGC and SAM to Co-locate for the First Time

by Dilip Ballal, IGTI Chair of Conferences

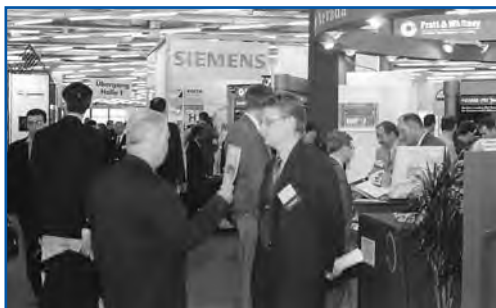
From 4-7 June, 2001, New Orleans, Louisiana (the Big Easy) will host the 46th edition of the most important annual meeting of the international gas turbine community, ASME TURBO EXPO - Land, Sea & Air (TE'01). Creating an exciting new synergy, ASME TURBO EXPO, the International Joint Power Generation Conference (IJPGC), and the ASME Summer Annual Meeting (SAM) will meet concurrently in this popular convention city. See sidebar for more information.

Since 1955, industry experts and practitioners have gathered at ASME TURBO EXPO to renew acquaintances, share new information, solve mutual problems and chart new directions for the technology. And 2001 will be no exception. The highly respected ASME TURBO EXPO for 2001 will be held at the Ernest Morial Convention Center in New Orleans. This event will feature a world-class Exposition (4-6 June), and an unparalleled Technical Congress and Users Symposium (4-7 June), from which all segments of the industry will derive benefits ... from engineers to managers to technicians, and from developers to users of large, medium and small machines in aircraft, pipeline, marine and land-based power applications. With over 100 technical sessions and end-user panels expected, there will be a wealth of information for everyone.

So far, the following key individuals have accepted our invitation to participate in this historic event:

- ❖ Mr. Geoff Roberts, President & CEO of Entergy Wholesale Operations, will serve as Executive Conference Chair for the ASME TURBO EXPO '01 Congress and Users Symposium. Entergy Wholesale Operations is the wholesale power development, risk management, marketing and trading business unit of Entergy Corporation. As a leader of Entergy's global development of power generation assets, Mr. Roberts brings a broad spectrum of user expertise and understanding of the power generation business to TE'01.

...continued on page 20



Relive the Adventure of TURBO EXPO 2000!

...See the Conference Wrap-up starting on page 16.



Geoff Roberts

This year, for the first time in its history, ASME TURBO EXPO will co-locate with two other ASME events, IJPGC and SAM. The International Joint Power Generation Conference (IJPGC) is an annual power industry conference and exposition, sponsored by ASME's Power, Nuclear, and Fuels & Combustion Technologies Divisions. The ASME Summer Annual Meeting (SAM) brings together 300 of ASME's top leaders for its annual business meeting. When their complementary audiences are combined, TURBO EXPO and IJPGC will bring more than 4,500 gas turbine and power industry professionals to New Orleans next June. Current plans call for TURBO EXPO and IJPGC to have separate congress registrations (with cross-over privileges) and a combined Keynote Session and Exposition. Cross-over privileges allow those registering for one congress to attend the technical sessions of both congresses.



VIEW FROM THE CHAIR

H. ALLAN KIDD, CHAIR, IGTI BOARD OF DIRECTORS

As the Baton is Passed . . . Some Thoughts

Back in 1995, when the IGTI Board of Directors was developing a multi-year strategic plan, we decided to make a conscious effort to improve our impact on an important segment of the gas turbine community. That focus was the owner, operator, and maintenance team or end-user. We recognized that the Technical Congress at ASME TURBO EXPO did a superior job in meeting the needs of academia and the research communities and we in no way intended to diminish that. Several of our Committees paid particular attention to gas turbine applications, and the Exposition provided a wealth of useful knowledge to the entire gas turbine community. However, we were not as successful as we wanted to be in reaching the end-user.

We decided to introduce a new track of programming entitled the Gas Turbine Users Symposium (GTUS). The format and content of the GTUS has been adjusted and improved each year since 1995 as we learned more about the needs of this user community. I'm sure that future GTUS Chairs will continue to build



H. Allan Kidd
Chair
IGTI Board of Directors

upon the foundation that has been laid; and, hopefully, see it grow to become as popular and successful as the traditional Technical Congress and Exposition.

In addition to programming changes, IGTI has been active in establishing strategic relationships with related organizations. One outstanding success will be demonstrated at TE'01 in New Orleans when ASME's IGTI and International Joint Power Generation Conference co-locate. We hope to see this relationship grow also.

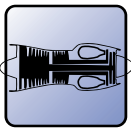
As I end my term as Chair, I would like to thank all of you who are actively involved in IGTI for making my responsibilities as a Board of Directors member one of the most personally and professionally rewarding experiences I have had. It has been a pleasure to serve you.

I would like to encourage the younger engineers to become active by writing a paper, chairing a session and becoming a leader within one of IGTI's Technical Committees. Keep making suggestions to drive IGTI leadership toward continuous improvement of the best gas turbine professional society there is. *



*... my responsibilities as a Board of Directors member
[has been] one of the most personally and professionally
rewarding experiences I have had.*





ROLLS-ROYCE PLC and **AVIC** (Aviation Industries of China) are to form a Joint Engineering Team (JET) to co-ordinate aero engine research and technology projects, concentrating on high-pressure, core engine and system integration technology.

GE POWER SYSTEMS announced early this year that it has completed a multi-year effort and secured agreements totaling nearly \$4 billion to supply power generation equipment and services to Duke Energy North America. The agreements cover the purchase of 84 gas turbines, 17 steam turbines and long-term service agreements for up to 23 merchant power plants across the country. When completed, the power plants will produce more than 13 gigawatts of power for the wholesale U.S. market.

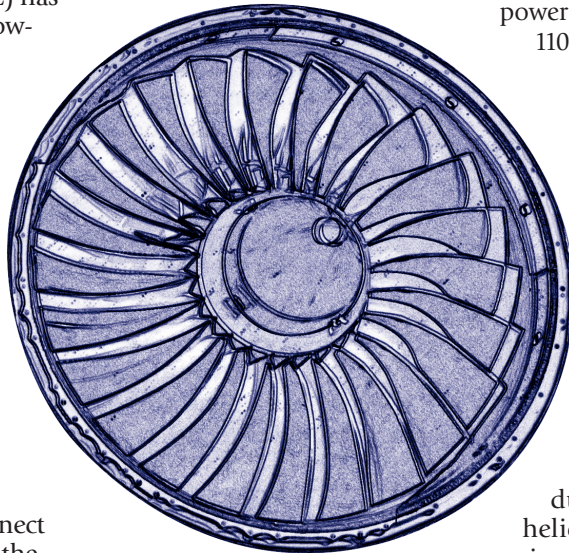
CAPSTONE TURBINE CORPORATION

announced Feb. 25 that Underwriter's Laboratory (UL) has approved Capstone's low-pressure gaseous fuel delivery system for use within the UL-listed Model 330 Capstone MicroTurbine(TM) power generator. The new listing is for a Model 330 variation that includes a built-in compressor that pressurizes the gaseous fuel to maximize efficiency. Both low-pressure and high-pressure Capstone MicroTurbine grid-connect systems are certified to the UL2200 standard, a newly developed set of criteria for power generators.

ROLLS-ROYCE announced in May that its Indianapolis engineering and manufacturing operation is the first gas turbine engine manufacturer to be certified to the ISO 14001 international environmental management standard in the United States. The ISO 14001 standard is designed to help companies manage their environmental affairs by ensuring compliance, preventing pollution, and providing for on-going improvement.

SECURE POWER SYSTEMS LTD. has installed the first microturbine cogeneration project in North America for Stellarton Energy Corp. at Stellarton's Carrot Creek Gas plant. The turbine went into commercial operation on Oct. 15, 1999 and has operated on a continuous basis since then, accumulating 2,200 hours of operating time. Stellarton's Carrot Creek Facility utilizes 709,000 Btu's/hr of heat produced by an Elliott TA45 microturbine to support an existing boiler. As well as providing standby power, the TA45 supplies 27kw to 37kw of continuous electric energy.

THE BOEING COMPANY and **GENERAL ELECTRIC** have launched two new longer-range models of the successful 777 airliner. GE Aircraft Engines has been working for two years to develop its low-risk, growth-derivative GE90-115B engines which will power the new 777-LR jets. The GE90-115B will be nominally-rated to 115,000 pounds thrust, and power the heavier 777-300LR. The engine will be derated to 110,000 pounds thrust for the 777-200LR as the GE90-110.



Secretary of Energy **BILL RICHARDSON** has announced that a revolutionary new type of fuel cell/gas turbine power plant has been built and will be installed for testing in Irvine, Calif. It is the latest innovation in the Department of Energy's fuel cell research program. The new 220-kilowatt Siemens Westinghouse power plant will be the first in the world to combine a fuel cell with a gas turbine.

GE and UNITED TECHNOLOGIES CORPORATION

have signed a Memorandum of Understanding (MOU) for a new military helicopter engine program. Under this MOU, the companies are negotiating a business venture that will compete for the U.S. Army's Common Engine Program (CEP). The CEP is a program envisioned to be used in growth applications of the Black Hawk, Apache and Seahawk helicopters, which are currently powered by GE's T700 engine.

PRATT & WHITNEY SMALL MILITARY ENGINES (SME) and TELEDYNE CONTINENTAL MOTORS (TCM)

have signed a Memorandum of Agreement to pursue teaming in areas of development, manufacturing, and technical and product support. This product line would include Uninhabited Air Vehicle (UAV) engines up to 16,000 pounds of thrust for U.S. Government customers. *

*Gas Turbine News in Brief ... is compiled for Global Gas Turbine News
by Carl E. Opdyke, Power Systems Aerospace Analyst, FORECAST INTERNATIONAL,
22 Commerce Road, Newtown, Connecticut 06470*



Fuel Cell / Gas Turbine Hybrid Power Systems for Distributed Generation

by Abbie Layne and Norm Holcombe ... National Energy Technology Laboratory

The Department of Energy's (DOE) mission is to develop clean, high-efficiency, electric power plants for the 21st century that can reduce CO, hydrocarbons, CO₂, SO_x, and NO_x emissions. To this end, a Hybrid Power Systems (HPS) program has been initiated. The objective of this program is to aid in the development of stationary power systems that will be at least 60 percent efficient (lower heating value) at converting fossil fuel to AC electricity and produce electricity at costs 10 to 20 percent below today's comparably sized power plants. Initially these systems are targeted for the distributed generation market and to be fueled with natural gas. Ultimately, these systems could be fueled with natural gas or coal.

This article outlines how the National Energy Technology Laboratory (NETL, formerly the Federal Energy Technology Center) will successfully develop and demonstrate fuel cell/gas turbine hybrid power systems to the stage that they are readily transferable to commercial industry through cooperative research and development partnerships.

Fuel Cells

Fuel cells generate DC electricity and heat using an electrochemical process superior to that of a battery. They continuously produce power as long as a fuel such as gas and an oxidant (air) are available (Figure 1). The DC electricity is then converted to AC. The most highly developed of these new units are the solid oxide fuel cell (SOFC) and the molten carbonate fuel cell (MCFC).

Companies currently manufacturing and selling stand-alone fuel cells include International Fuel Cells (IFC), Fuel Cell Energy (formerly Energy Research Corp.), and Siemens Westinghouse Power Corporation (SWPC). Although commercially available, current technologies have a high cost per kW of power produced.

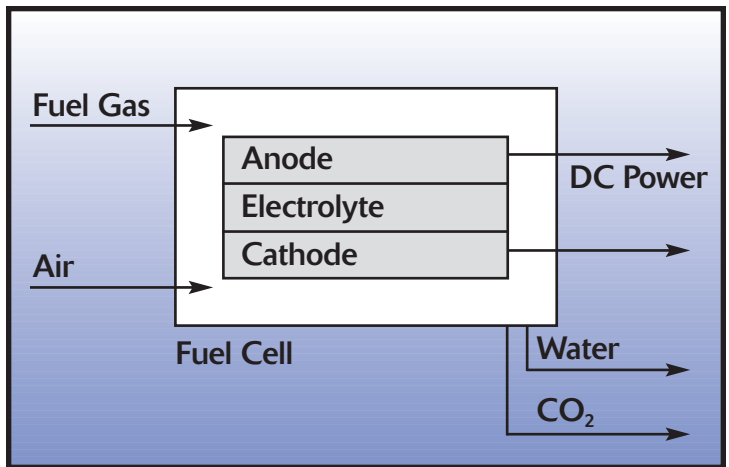


Figure 1. Fuel Cell Schematic.

Task Force on Fuel Cell / Gas Turbine Hybrid Power Systems

Because of the significance of microturbines, fuel cells and hybrid power systems to the future of gas turbines and distributed generation, the topics related to this technology will be a featured part of TE'01 in New Orleans next June. To accomplish this, the IGTI Board of Directors is establishing an ad-hoc Task Force to work with IGTI Technical Committees and other volunteers. Those interested in submitting papers or proposals for tutorials / panels should contact the relevant Technical Committee point contact by referring to the listing on the web at: www.asme.org/igti/te2001.

Fuel Cell/Heat Engine Hybrid Systems

Power producing systems containing a combination of high-temperature fuel cells and heat engines (e.g. gas turbines) have the potential for very high efficiency in converting fossil fuel to AC electricity. Hybrid cycles are myriad and can include combinations of fuel cells with gas turbine engines, steam turbines, or even reciprocating engines. Fuel cell/gas turbine cycles have been the first such hybrid systems developed to-date. Steam turbine systems, though less efficient, may also have an important role in helping some fuel cell technologies achieve high efficiency.

Hybrid systems offer a solution to two important problems ... the low efficiency and relatively high emissions of small gas turbines, and the high cost of small fuel cell power plants.

When used in combination with turbines, fuel cells can produce from 55 – 90% of the electricity of the system while turbines produce the remainder. Several cycle configurations have been proposed and the terminology is still evolving, but one useful way of looking at the differences is to divide the configurations into those that include "directly fired turbines"



and those with "indirectly fired turbines." A hybrid power system with a "directly fired turbine" normally uses a pressurized fuel cell to provide input to the turbine, thus acting as a combustor. In the "indirectly fired turbine" system an atmospheric fuel cell is used and a pressurized heat exchanger provides input to the turbine. When utilizing the fuel cell/gas turbine combination the combined efficiency of the system is raised to greater than 60 percent and criteria pollutant emissions are essentially eliminated.

An example of a hybrid system with a "directly fired turbine" is shown in Figure 2. This generic system is similar to that first proposed by Siemens Westinghouse and consists of a pressurized solid oxide fuel cell (SOFC) module which is positioned at the turbine inlet with an oxidizer in between. The SOFC fuel cell acts as the combustor for the turbine. The oxidizer is part of the fuel cell and finishes the combustion process. The SOFC system is combined with a power conditioning system that converts DC power from the SOFC to the AC form that will be required for use.

Various other cycles can be considered for solid oxide fuel cells (SOFCs) and molten carbonate fuel cells (MCFCs). MCFCs operate at lower temperatures than SOFCs and thus may require different system designs and offer distinct features and advantages depending upon the application.

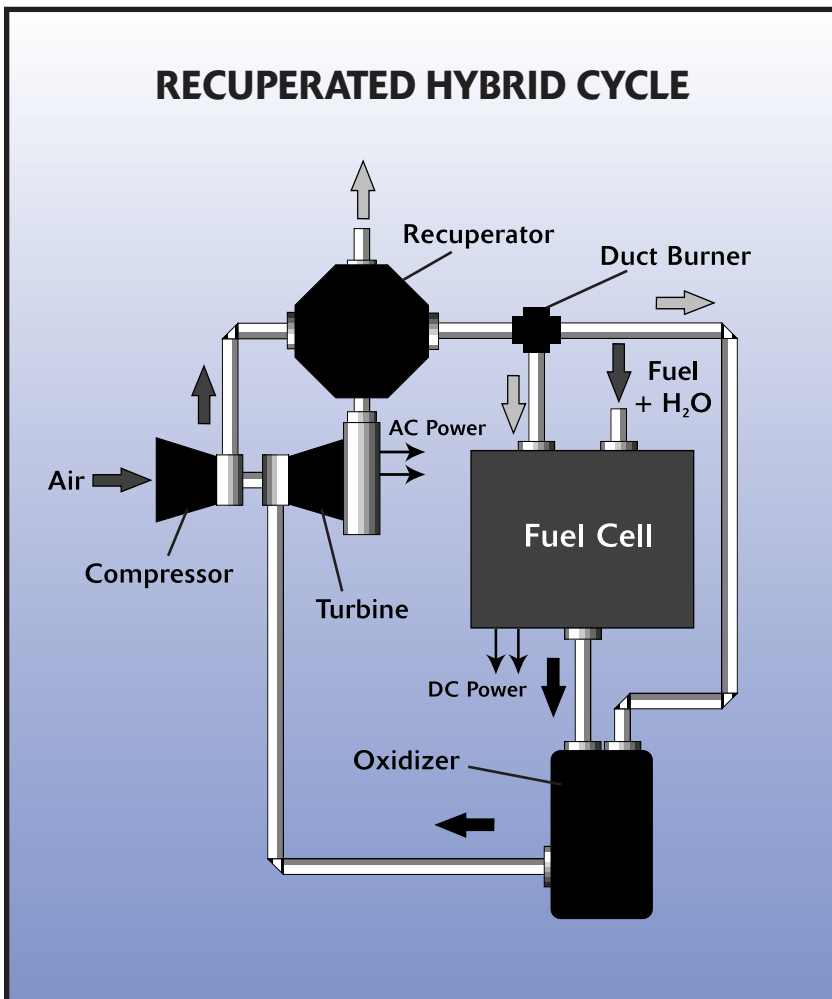


Figure 2. Generic recuperated hybrid fuel cell/gas turbine cycle.

Technical Goals

- **Near Term Hybrid Systems** (Demonstrated by the year 2002-2005) - Systems under consideration shall be for stationary power, up to 1 MW in size, and must convert fossil fuel to electricity at > 60% efficiency (LHV) operating on natural gas, and at least 45% efficiency (HHV) operating on coal.
- **Mid-Term Hybrid Systems** (Demonstrated by the year 2010) - Systems under consideration shall be for stationary power, less than 20 megawatts in capacity and must be at least 70 percent efficient (LHV) at converting natural gas and 53% efficient (HHV) at converting coal to AC electricity. Electricity generated should cost 10 to 20 percent below today's comparably sized conventional power plants.
- **Long-Term Hybrid Systems** (Demonstration by the year 2015) - Systems under consideration shall be for stationary power and must be at least 80 percent efficient (LHV) at converting natural gas and 60% efficient (HHV) at converting coal to AC electricity.

Stakeholders

NETL recognizes the importance of establishing partnerships to the successful development and commercial use of hybrid systems. Identification and communication with stakeholders is of primary importance. NETL has established the following categories of partners to be necessary for a successful program: developers/manufacturers, funding providers, financiers and users. These will include small businesses, industry, academia, national labs, other government agencies and congress. The partners will help with the research, development, and demonstration of hybrid systems and also will provide financial support. Design issues that are specific to the gas turbine and the fuel cell would be handled by the respective base programs (the Advanced Turbine and Engine Program, and the Fuel Cell Program). Funding for the HPS will initially be shared by these two programs with subsequent development of hybrid specific funding subject to budget authorizations.

Market Assessment

The near and mid-term market for Hybrid Power Systems (HPS) is expected to be similar to that for fuel cells. The distributed generation (DG) market will be the primary application. Distributed generation refers to genera-



“
Initial success at developing a hybrid fuel cell / gas turbine system went to a cooperative effort between Westinghouse Science & Technology Center (fuel cell) and Northern Research and Engineering Corp. (turbine) in 1995.
 ”

tion at or near the customer site (including substation and feeder lines). It offers the potential for a more reliable and cleaner alternative to large central station power generation and the concomitant transmission and distribution problems, and it has the potential to be deployed by utilities, generators and end users (industrial, commercial, and residential). The opportunity for DG is for the following size ranges: Small residential and commercial, less than 500 kW; medium commercial and industrial, 0.5 to 5 MW; and large industrial, 5 to 50 MW. Market estimates for DG vary significantly ... from 2,500 MW per year to 10,000 MW per year by 2010. Competitors of Hybrid Power Systems in this market are fuel cells, gas turbine combined cycles, recuperated gas turbines, reciprocating engines, photovoltaics, and wind.

As with many emerging technologies, certain types of customers will likely be early adopters of SOFC and MCFC hybrid technologies. NETL has commissioned a study to determine which commercial sectors and companies are most likely to be early adopters. The study will focus on high efficiency MCFC and SOFC hybrid technologies as well as competing systems such as gas turbines, reciprocating engines, and traditional grid service. The report will identify specific regions in the country where these technologies and the corresponding early adopters are likely to be located. This will enable the system developers to accurately target and begin SOFC and MCFC hybrid promotion.

The tasks involved in the study are as follows:

Task 1 - Profile Early Adopters to identify general and specific characteristics that may influence a customer to become an early adopter of MCFC and SOFC hybrids.

Task 2 - Expand Disaggregation of Market Segments by using data to help determine which specific customer segments may be early adopters. The markets for 500 kW and 1 MW MCFC-GT and SOFC-GT and for 2-20 MW MCFC-GT and SOFC-GT systems will be expanded and disaggregated. Estimates will be made of the market potential for each technology.

Task 3 - Identify Early Adopters by matching the customer segments identified in Task 2 with the lists of characteristics identified in Task 1. Each segment will be scored for each trait/characteristic in order to develop a ranking of segments by likelihood of early adoption. Leading sectors, companies and regions will be identified. Probable early adopters for each of the emerging technologies will be identified.

Task 4 - Develop Strategy for Pursuing Early Adopters. Leading segments from Task 3 will be profiled, indicating leverage points and highlighting the basis for expected early adoption. Leading companies in individual sectors will also be discussed. Strategies for pursuing each sector will be recommended. Resources needed to bridge the gap between early adopters and the early and late majority of buyers will also be estimated.

Task 5 - Prepare Final Report. Results will be presented by technology, sector, size range, state, and ownership scenario. Conclusions will be drawn and recommendations made. The report will provide the blueprint for the emerging new distributed generation business and how to identify those commercial and industrial sector customers most likely to be early adopters of new generation technologies.

Rolls-Royce Allison was commissioned to conduct the above evaluation of the Hybrid Power Systems market using an outside contractor. The study should be complete later this year.

Historical Systems Development

Initial success at developing a hybrid fuel cell/gas turbine system went to a cooperative effort between Westinghouse Science & Technology Center (fuel cell) and Northern Research and Engineering Corp. (turbine) in 1995. They developed a 220 kW hybrid system that has run and is still being tested.

A second generation of effort in the HPS arena arose as a result of NETL initiatives. As a result of two public workshops to evaluate the potential and technical barriers for developing an ultra high efficiency hybrid system, NETL issued a Program Research & Development Announcement (PRDA) for a conceptual design and feasibility study of possible high efficiency fossil-fueled power plant concepts. Only near term systems of less than 20 MW were considered. These systems were also to be at least 70 percent efficient (lower heating value) at converting fossil fuel to AC electricity and produce electricity at costs 10 to 20 percent below today's conventional plants. In the summer of 1998, five contracts were awarded. All five of these contracts dealt with the feasibility and systems studies of fuel cell/gas turbine combined power systems. The awards were for approximately \$200,000 each.

The feasibility and systems study awards granted by NETL for fuel cell/gas turbine hybrid systems are summarized in Table 1. Each of the awards represented the teaming of a fuel cell manufacturer and a turbine manufacturer. Three of the awards were for solid oxide fuel cell





(SOFC) hybrids while two of the awards investigated molten carbonate fuel cell (MCFC) hybrids. All manufacturers successfully developed conceptual designs for technically feasible, natural gas fired power systems with capability of near 60% (LHV) electric efficiency or better. Of course, these were "paper studies" with their practicality yet to be proven.

TABLE 1

Fuel Cell Manufacturer	Turbine Manufacturer	Type of Fuel Cell
Westinghouse Science & Technology Center (now Siemens Westinghouse Power Corporation)	Allison Engine Company (now Rolls-Royce Allison)	Tubular Solid Oxide
Westinghouse Science & Technology Center (now Siemens Westinghouse Power Corporation)	Caterpillar/Solar Turbines	Tubular Solid Oxide (uses stackable tubes in its configuration)
Energy Research Corporation (now Fuel Cell Energy)	Allison Engine Company (now Rolls-Royce Allison)	Molten Carbonate
M-C Power (now out of business)	Allison Engine Company (now Rolls-Royce Allison)	Molten Carbonate
McDermott/SOFCO	Northern Research and Engineering Corp.	Planar Solid Oxide (uses stackable flat plates)

NETL In-house Research

NETL is funding an in-house project that will provide information on the critical technical issues that need to be addressed when integrating fuel cells and gas turbine engines. Past workshops on hybrid technology have suggested that the dynamic control of these combined systems will need special consideration to ensure reliable and safe operation. The project, referred to as the Hybrid Performance project (HYPER), involves experimental evaluation of a combined 75 kW turbine and simulated fuel cell. The specific goal of this work is to provide experimental data on the dynamic performance of hybrid systems. The activity will identify the operational parameters that affect safe operation, including startup/shutdown, part load, and load upset conditions. Further insights to these issues will be obtained by the development of dynamic modeling tools. This element of the work is being done in partnership with the National Fuel Cell Research Center at the University of California at Irvine.

As a result of this work, an independent evaluation of hybrid technology will be provided to DOE R&D planners. In addition, new software tools to support the design of these systems will be made available.

In addition to the above, NETL Process Engineering Division has conducted a hybrid systems analysis. Proposed concepts have been compared on the basis of projected performance, development requirements, stakeholder interest, and

other factors. Process simulation and model development, spreadsheet analysis, and cost estimating were undertaken for concepts in support of strategic planning, solicitation development, and proposal reviews throughout the life of the hybrids program. The analysis is soon to be complete.

Current Status and Near Term Efforts

By the time this article is published the deadline of June 27 for the next NETL solicitation will have been reached. This solicitation was for proposals that will use existing and near term equipment (fuel cells and gas turbines) to get a hybrid system up and running so that problems can be identified. The objective is not to conduct fuel cell and turbine research, but to conduct research into issues of systems integration. Proposals will be evaluated and awards made in December of this year.

Contracts awarded will be on a cost sharing basis and will proceed in three phases. The first phase receives 80% NETL support and focuses on the identification of barrier issues to systems integration. The second phase is 65% supported and is to result in a systems design and cost analysis. The third and final phase is 50% supported by NETL and is to result in the operation and testing of a proof-of-concept hybrid system. A proof-of-concept system is the smallest system that will adequately test all of the individual components in a fully operating system.

Future solicitations and awards will likely be made regarding issues of increased efficiencies, reduced costs and increased system capacities. *



Taking Stock of the Gas Turbine Industry... The Wall Street Perspective

by Wolfgang H. Demisch ... Managing Director of Wasserstein Perella Securities, Inc.

The following is the text of Mr. Demisch's excellent Keynote presentation at ASME TURBO EXPO 2000 in Munich, Germany this past May. Managing Director of Wasserstein Perella Securities, Inc., Mr. Demisch has over 20 years experience as a senior analyst and is responsible for coverage of aerospace, defense, and high technology industrial companies. His comments present an interesting perspective on our industry's development and future. Section titles have been added for clarity. (Ed.)



Wolfgang H. Demisch

State Minister Wiesheu, Mayor Monatzeder, fellow members of ASME, honored guests: It is a real pleasure to have the opportunity to speak with you here, in beautiful Bavaria, to help kick off TURBO EXPO 2000, the 45th gas turbine conference sponsored by ASME. It is fitting that this first 21st century TURBO EXPO should take place in Germany, the country where the aeronautic gas turbine first took flight, some 60 years ago.

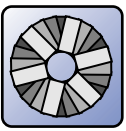
That event took place within the lifetime of some of us here. Indeed, just yesterday I was privileged to attend an award ceremony for Martin C. Hemsworth, who has been active in gas turbine technology since 1940. Marty was a driving force behind GE's TF39, the world's first high bypass jet engine. As his presence illustrates, we have our history present here with us. Since that first flight, gas turbines have passed many milestones. Forty years ago, gas turbines began to transform commercial air transport. Thirty years ago travel became a mass market by virtue of efficient high bypass engines and widebody jets. Twenty years ago deregulation began in the U.S. airline sector and utility industry, making cost a central issue. Ten years ago the cold war ended and the global economy began to integrate more fully, spurred by ongoing deregulation and privatization worldwide.

TURBO EXPO 2000, here at the beginning of a new decade and a new century, is an appropriate occasion for taking stock. This conference exists not only to look forward to the new capabilities that the new technologies you are creating make possible, but also to provide a wider view ... to look at the framework in which the global gas turbine industry is set to grow. We do ourselves a disservice if we fail to step back for a periodic reality check, especially in an industry as multifaceted in its relationships, as complex in its technologies and as long term in its product life cycle as the gas turbine business is today.

Taking Stock

For any industry, stocktaking must begin with an assessment of its markets, the customers it serves and hopes to serve, followed by an examination of how the customers' needs and challenges translate into requirements and priorities for that industry. Such assessments are an ongoing requirement in the financial community. Wall Street, which we can use as shorthand for the entire finance and investment component of the economy, is as you know primarily a futures discounting mechanism. Investors value businesses based on the discounted present day value of their projected future earnings stream. Greater expectations bring about higher values. Of course, investors discount their expectations more severely if there is greater political, technological or operational uncertainty than is the norm for securities in general. These uncertainties are very familiar in the gas turbine business.





In Wall Street's eyes, the gas turbine industry constitutes a critical enabling technology that... has never been able to adequately exploit the economic value of its technology.

So my objective this morning is to provide a Wall Street perspective on the industry as it enters this new era of 21st century peace and prosperity, and to lay out some possible implications for this sector of the transition to a global economy now underway.

Historical View

In Wall Street's eyes, the gas turbine industry constitutes a critical enabling technology that has also been intimately linked with government controlled markets for most of its existence. It produces the military engines that were critical to national security, powering aircraft, helicopters warships and tanks, plus it opened the world to large scale global air transport service, offered by both private as well as nationally owned carriers. In addition, its compressor and power generators have carved out a substantial and growing share of the gas and electric utility capital budgets, thanks to their efficiency, reliability and relatively speedy construction cycle.

This relationship with government customers has been technically constructive. The U.S.'s DOD, the UK's MOD and their counterparts elsewhere fostered the development of gas turbine technology, as have a host of other agencies, such as NASA, DARPA and EPRI in the U.S. Government requirements and funds have provided most to the push that has lifted the capabilities and performance of gas turbines from the initial 1000 lb thrust engines to over 100,000 lbs. today, while boosting overhaul cycle times from tens of hours to tens of thousands of hours along with a tripling of fuel efficiency.

The downside to these government relationships is that the industry has never been able to adequately exploit the economic value of its technology. With multiple sponsored suppliers and customers, the industry has recapitulated the experience of the semiconductor industry, another enabling technology that was deemed vital for national success by numerous governments. "Industrial rice" was the term used, and as a result, that industry, which has maintained over 20%/year productivity improvement for the past 40 years, still consists mostly of intermittently profitable suppliers earning under 20% from operations. Only Intel, which almost uniquely made the transition to a system provider, has been able to achieve and to maintain the 40-50% margins that appear appropriate for a world leading producer of critical technology products. While the rest of the semiconductor industry still faces a difficult adjustment now that the Asian economic crisis has curtailed its

capital sources, Intel carries a P/E in the forties and enjoys a market valuation approaching 10 times annual sales. The gas turbine producers unfortunately have not achieved similar recognition. In fact, Rolls-Royce, the most focused supplier, carries a barely double digit P/E, while critical component producers such as Precision Castparts or Howmet sell for less than 20 times. Only GE has won the financial markets unre-served endorsement, probably because GE has long stressed the financial performance of its business as much as their operating quality. In any case, the gas turbine industry faces a transition, perhaps less abrupt than do semiconductors, but no less far reaching.

Recent Changes

The end of the Cold War and the collapse of the centrally planned economy model combined imply a dramatic change in the industry's business framework. First and most obviously, there has been a brutal slump in military purchases. While overall budgets have dropped only 20-40%, equipment purchases have fallen to a third or less of prior norms. Production is averaging 1-2% of the active inventory versus 6-10%, and new program developments are being stretched over 15-20 years. Keeping design teams intact and production lines open in this framework is problematic at best.

Apart from the obvious volume impacts, the ending of the global confrontation has opened previously blocked avenues for global teaming and rationalization. The Rolls-Royce Allison merger and the UTX-PERMI cooperation illustrate the possibilities opened up. By extension, the national security umbrella over this sector is being withdrawn, so local industry can become global, if required, but must also face up to global competition.

There is a similar transition for the commercial customers. Air transport has become a purely economic activity with the arrival of peace. Much as the 1930's vintage national shipping lines have in peacetime been overtaken by private enterprises such as Maersk or Carnival Cruises. The world's national air carriers are well along in a process of privatization and consolidation.

Starting with the tremendous success of deregulation in the U.S. in the late 1970s airlines worldwide have increasingly become profit oriented rather than nationally sponsored entities. Their growth continues, but profit is now the key.

Similarly, the world's power industry, which now represents the fastest growing market for gas turbines, is stepping out of its long established



regulatory framework, and embracing a private market competitive structure. As Asia gradually recovers, and as U.S. and European producers act to restore supply margins and to meet lower emission requirements, this sector should continue to grow handsomely but with global competition to serve its equipment needs.

The clear implication of the above changes in the customer environment is that we are now in a buyers' market. Economic return is becoming the primary driver for the world's airlines and for the world's utilities, rather than political or social priorities. Likewise for the military, overburdened with responsibilities that mandate a high operating tempo in peacetime, cost will increasingly be the crucial variable in purchasing decisions.

This shift in customer priority from performance to cost is not entirely unexpected. The industry has in any event begun to reach practical technical limits to the benefits from its historic priorities of more powerful, more economical to run and more durable. For one, there is no aircraft in prospect that would justify an all new engine beyond the GE90/115B, nor is there much likelihood of a much greater fuel efficiency. While an unducted fan might offer a good gain, as could an engine with much higher temperatures or pressure ratios, the price of the extra complexity and capital required might require a \$100/bbl oil price to justify the needed investments. That price fortunately still appears some ways off. Nor is durability as much of an issue, at least in aviation, as the airframe itself typically needs an overhaul after 5 years or 15,000 hours, much as engines do now. Only a life of the aircraft maintenance free engine, which would appear to be within reach during the next decade, probably initially for corporate jets, might well become an economically attractive proposition for both military as well as civil users, subject to regulatory approvals.



Implications and Future Strategies

The implications for the industry are profound. It means the gas turbine product space is now broadly defined in size and performance, so that future gains here can only be achieved by taking share from a competitor. Of course, this does imply a further intensified struggle for competitive advantage, but the impact is felt more in the equity market. Financial markets, as noted earlier, focus on future earnings prospects. If those prospects come under pressure, so does the share price. To the extent that any of your firms use options as a compensation tool, or as a recruitment incentive, or you carry company stock in your retirement accounts, this is a very burdensome development.

To avoid these undesirable consequences, the gas turbine industry must do one or more of the following 1) develop new markets, 2) serve its existing markets much more cost effectively, or 3) restructure to capture more of its economic value than it does at present.

Develop New Markets

Of these options, the first is perhaps the most uncertain, not because there is no market, but because it is brutally difficult. There is in fact an enormous market for smaller power sources, starting with local generators, power sources and long haul rail and truck engines, and eventually going down to automotive engines. Indeed, there is even research underway for micro scale gas turbines to act as battery substitutes. Considering that we are selling hundreds of millions of portable devices per year, whose battery prices are in the \$100 class for computers and cell phones, this implies a market in the \$10 billion class. There is clearly plenty of opportunity even at the smallest end, if we can produce a workable design to address it.

More broadly, there is plenty of room in the mid range, the 50-500 hp class. Even before factoring in speculation about multi-billion dollar markets for distributed power generation, bypassing the increasingly unreliable grid, as has been an element in supporting new industrial sites in China and elsewhere in Asia, there are huge opportunities in the automotive market. With a third to a half million heavy trucks sold annually worldwide, powered by engines whose prices are in the \$20,000 class, there is a large business opportunity for a low emission, low vibration, ultra reliable lightweight turbine. The gap is the turbine's much higher cost relative to that of the reciprocating engine. Even though



investors would certainly flock to support a venture that offered a plausible and adequately inexpensive alternative to the diesel, probably a regenerative design centered on a ceramic hot section, it currently seems painfully far from reality. Sam Williams, whose Williams Research is probably the best small engine supplier in the world today, helped pioneer the 1950's vintage Chrysler turbine car. Even he is not yet claiming to be close to a commercial solution. But the opportunity remains open.

Better Serve Existing Markets

Systems cost reduction is a much more workable alternative, if only because it aligns the interests of the shareholder and the engineers so closely. The gas turbine industry is still living in the paper age, at least in the eyes of outside investors, rather than leading the way into the electronic era. The entire process, beginning with the parts definitions, the design documentation plus the sales contracts, the installation procedures, the maintenance records and the repair documentation should be a seamless, integrated whole, on line, universally accessible and cross linked, rather than requiring the kilograms of documents that it does today.

The entire system is crying out for standards. Yet even for an item as simple as fasteners the part identifier may be different at Pratt than at Fairchild or at Huck, so that duplication and non value added cost is the order of the day. Multiply these costs by factoring in the repetitive paperwork of documentation, which is peculiar to each industry major, and the lack of common processes, results in a non-economic cost which has been estimated at as much as 30%. As long as these were mandated by governments and regulators, they were largely unavoidable; but at least they were non-discriminatory.

With deregulation and the de-emphasis on mil spec however, the opportunity exists to achieve significantly improved productivity by streamlining the processes and linking the technologists, the regulators and decision makers online. Unfortunately, we appear to be about to reinvent the tower of Babel, as GE launches its web based data integration, distinct from a similar Honeywell/UTX initiative, which in turn is distinct from either the Rolls-Royce or the Boeing—Bae—Lockheed Martin—Raytheon e-commerce efforts.

It is easy to understand the reason for these

parallel efforts. The task is hard enough to be barely manageable just for one firm and urgent enough to mandate immediate progress, whereas it would possibly take forever if everybody else had to be integrated simultaneously. It remains that the end result may be a jumble of incompatible solutions wherein neither the regulators nor the customers, both of whom deal with a broad cross section of the gas turbine industry, will be well served. There needs to be at least a neutral forum to try to ensure some basic standards before too much money is spent. We need ASME/DIN templates for e-commerce in the aerospace/gas turbine world.



It should be possible to get some agreement to coordinate on the standards simply because it is in everyone's interest to do so. A non standard process impedes cooperation and forces customer/supplier communications back into paper, a higher cost alternative. Of course, the longer term implication is that while these process upgrades can help shift resources toward new product development and manufacturing efficiency improvements as well as profit and away from administrative overheads, there is unlikely to be sustainable

competitive advantage from this change. Everyone will have the new systems, in some form, as a matter of survival. Hence the industry may become leaner and quicker with these new tools, but remain just as inadequately profitable if the participants surrender these gains in the pursuit of market share.

Capture More Economic Value

The best hope then is the third option for the industry, to restructure, to capture more of its economic value. We noted earlier that gas turbines represent an enabling technology, but that presumably by virtue of its government gestation, it has not learned to capture the value added it provides to its customers. An extreme illustration was the suicidal three way contest to power the 777, which ensured that neither Boeing nor its engine suppliers are in near term danger of earning any return on their investment here. At least Boeing and Airbus have clearly taken these lessons to heart, as evidenced in the more recent sole source engine supply arrangements on the 777-X and the A340-500/600. Even here, however, the engine suppliers remain substantially at risk, having granted launch financing and considerable price concessions.



“
**Probably
 there will be
 more industry
 consolidation
 ...
 surviving
 firms, how-
 ever, will
 flourish
 mightily ...**
 ”

In short, from a financial perspective, the gas turbine industry is not structured right. The OEMs compete ferociously to win commercial order, but have not adequately tied up the aftermarket which has historically been their ticket to financial survival. This suggests two solutions. One might be to sharply reduce the number of OEMs, perhaps linking other major aero engine makers with heavy turbine builders, following the GE experience. However, the recent Boeing/Airbus experience proves that even two suppliers are still quite sufficient for a price war, so reducing the number of OEMs may be an inadequate response.

A more promising solution would be for the OEMs to emphasize capture of the aftermarket, to retain the highly profitable spares and support tail generated by engine overhauls. This aftermarket emphasis, although long the source of the industry's profitability, has eroded over time as third party suppliers have captured Parts Manufacturing Authority (PMA's) for individual high volume components and as subcontractors have broadened their presence. In the developing global supply chain, linked by electronic data bases of design and manufacturing parameters, it is likely that such competitive pressures will increase, despite regulatory constraints.

To reverse these trends, the OEM suppliers are already moving aggressively to evolve their customer relationship from a one time sale into a long term supply agreement. The objective is to balance the volatile and price sensitive new product sales with the less volatile and better margined services volume generated by the installed base. The active inventory of engines represents about 15 years of OEM production. Given a 3-5 year overhaul cycle and a 25-40% overhaul cost, it follows that turbine manufacturers' sales could double if they capture the entire service business. Towards that end, the engine makers' strategy to

date has centered on acquiring comprehensive aftermarket service capacity, by rolling up independent and airline operations. In addition, the OEM's are seeking to tie the customer into a much more comprehensive performance monitoring network. Together, this allows much better focused preventative maintenance, improving reliability while lowering cost. However, the need to provide not only engine but also air-frame maintenance, and to do so for multiple types, even from competing suppliers, will be burdensome for the OEM's. It is a much more challenging management responsibility to coordinate the flow of disparate but complex tasks. One blessing is that it should sharply increase the OEM's interest in the more integrated e-business framework suggested earlier, because that would help contain the costs of the more extensive services they are committing to.

Conclusion

From an engineering perspective then, the gas turbine industry is truly in transition. The broad customer focus has shifted from performance to cost, or at least, performance at a cost, while the suppliers are adapting to global from local sourcing, to embracing e-commerce and commercial practices instead of mil spec, conscious of the need to demonstrate competitive returns in an open marketplace without guarantees. Probably there will be more industry consolidation as part of this adaptation.

The surviving firms, however, will flourish mightily because the core benefits of the gas turbine remain unmatched, and are still fueling well above GDP growth for this sector in the global economy. As the industry harmonizes with these new requirements, you will find the financial community quick to reward the successful adapters with the kind of substantial valuation premium that your talents and skills should command. *

Gas Turbine Certification

During ASME TURBO EXPO 2000, two panel/discussion sessions were held concerning gas turbine certification, standardization and conformity assessment. A report on the discussions and ASME/IGTI activity in these areas will be in the October issue of this newsletter.





E-COMMITTEE . . . a model

by Geoff Sheard, Rolls-Royce plc ... Chair, IGTI Controls, Diagnostics & Instrumentation Committee and Neil Tyrrell, Rolls-Royce plc ... Member, IGTI Controls, Diagnostics & Instrumentation Committee

On the Controls, Diagnostics & Instrumentation (CDI) Committee, we realize that the Technical Committees are the heart of IGTI ... coordinating the activity of volunteers, and playing a key role in the process of producing paper and panel sessions for Turbo Expo. However, as each year passes, it seems to become harder and harder to find the time to organize sessions, seek out reviewers and coordinate with the authors.

A key strategic aim of the CDI Committee over the last year has been to focus on two central issues. Firstly, session organizer work load, with the objective of reducing it by 80%. Secondly, committee member involvement, with the objective of ensuring that every member has the opportunity to review every paper relevant to his specific competencies.

Segmenting our Market

The first stage in this effort was to understand who our members actually were. The committee database contained only the basic information, name and contact details. In order to understand who our members were, and something about them, a supplemental "Review Preference Form" (RPF) was developed (Figure One). This allowed our members to indicate which areas of activity they were specifically interested in. This work constituted a basic segmentation of the committee members.

The first stage ... was to understand who our members actually were.

Data Management

The first issue that the RPF raised was that some members had either moved on, or simply lost interest in continuing. Over the past two years inactive members have been systematically identified and removed from the committee database. This has resulted in a smaller, but active, core of members.

The process of consolidation and segmentation of the committee membership included the addition of email addresses for virtually all active members. This made the task of writing to mem-

Controls, Diagnostics and Instrumentation Committee Review Preference Form			
Please complete and return this form. The completion of this form is a pre-requisite to remain a member of the Controls, Diagnostics and Instrumentation Committee, failure to will result in removal from the committee and deletion from the IGTI Who's Who.			
Section 1: Member			
Title	First Name	Last Name	Email Address
.....
Section 2: Business Establishment Group			
Do you work in Industry, Education or a Government establishment?			Industry
Section 3: Review Preferences			
CONTROLS	DIAGNOSTICS	INSTRUMENTATION	
<input type="checkbox"/> Active Stall Control Methods	<input type="checkbox"/> Predictive Maintenance Systems	<input type="checkbox"/> New Sensor Concepts	
<input type="checkbox"/> Gas Turbine Control Systems	<input type="checkbox"/> Diagnostic Systems	<input type="checkbox"/> New Measurement Techniques	
<input type="checkbox"/> Pipeline Controls	<input type="checkbox"/> Monitoring Strategy	<input type="checkbox"/> Instrumentation for Development Engines	
<input type="checkbox"/> Control Review Papers	<input type="checkbox"/> Maintenance Strategy	<input type="checkbox"/> Production Engine Instrumentation	
<input type="checkbox"/> Control Tutorial Papers	<input type="checkbox"/> Operating Strategy	<input type="checkbox"/> Data Acquisition Systems	
	<input type="checkbox"/> Diagnostics Review Papers	<input type="checkbox"/> Instrumentation Review Papers	
<input type="checkbox"/> Other Controls (please specify)	<input type="checkbox"/> Diagnostics Tutorial Papers	<input type="checkbox"/> Instrumentation Tutorial Papers	
	<input type="checkbox"/> Other Diagnostics (please specify)	<input type="checkbox"/> Other Instrumentation (please specify)	
Section 4: Activity Summary			
How many papers have you reviewed for the 1999 & 2000 Turbo Expo's?			
How many papers have you published in the last 2 years?			
How many IGTI Turbo Expo's have you attended?			
Do you plan to attend the New Orleans Turbo Expo in 2001?			Yes
Would you like to become involved in the C & D committee organization & leadership team?			Yes
Do you plan to publish at Turbo Expo 2000?			Yes
Return to: Geoff Sheard, Rolls-Royce plc, FAX +44 (0) 24 7662 4060 or EMAIL anthony.sheard@rolls-royce.com (2000 RPF)			
Thank you for taking the time to fill in and return this form.			

Figure One: The CDI Review Preference Form (RPF)





bers much easier, because to send an email to one hundred people takes no longer than to send it to one. To print out a hundred letters, sign them, put them in envelopes, address and post them was, by comparison, an enormous task. The move to email, then, facilitated regular communication with the members - something that has simply not happened in the past.

The data from the RPF was entered into an Access database. In this way reports could be run to help identify sub-groups. An example would be the sub-group that had answered "yes" to the question "Would you like to become more involved in the leadership of your committee?" Each member who had answered "yes" received emails about the intended session schedule for the Munich Turbo Expo 2000, and again for the New Orleans event in '01. In this way every member who expressed an interest in becoming a part of the leadership team was given the opportunity to volunteer for one of several session organizer, chair and vice chair vacancies.

A second issue that became clear as the database was used to run reports was the frequency with which certain key reports were used. Session organizers were using the database to identify potential reviewers. They would then copy reviewer email addresses out of the database and send them a Word file containing the paper abstract.

This process was automated, with the development of the "review matrix" (Figure Two). This is a three by three matrix, with controls / diagnostics / instrumentation on one axis and industry / government / academia on the other axis. Information is extracted from the database on each member, and his email address entered into all appropriate boxes of the matrix. We estimate that the availability of this matrix reduced the time it took to identify suitable reviewers by over 90%.

Business Process Model

The developments described so far are all logical applications of email to the IGTI "paper production" process. In order to better understand the implications of what had been done, the paper production process was mapped (Figure Three) from the authors', session organizer's and committee point contact's perspectives. Essentially, the move to email and use of a membership database to generate a review matrix had split the point contact's activity into "front office" and "back office" functions. The front office function is the traditional role of the point contact. The back office function is the management of the member information, via the Review Preference Form (RPF) and database plus the creation of the matrix. From the session organizer's perspective, the existence of this

back office function is helpful only if it can be accessed easily. For the Munich Turbo Expo this was achieved by sending each session organizer every member's RPF, and the matrix. The mapped business process, however, pointed the way to a further automation of the process.

Future Development

The back office functions were ideal candidates for incorporation into the CDI Committee web site (a part of the IGTI web site). The RPF then becomes one page on the CDI web site, with members being able to register, or update their information on line. The Access database is also moved onto the web site, to enable the information from the RPF to be converted in real time into an update of the review matrix. In this way the review matrix becomes a living document, with session organizers being able to use current email addresses from the matrix, and in so doing involve members immediately after they have registered with the committee. This move to the web also automates the production of the matrix, and in so doing eliminates all work associated with its maintenance.

At the time of this writing, the CDI Committee is also experimenting with password protected web areas, with the intent of exploring this idea further over the coming year.

Review Preference Affiliation	Controls	Diagnostics	Instrumentation
Academia	Each box is filled with lists of names and e-mail addresses of people who have responded to the RPF, meeting the box matrix cross-reference. A name can be repeated in up to three boxes limited by affiliation.		
Government			
Industry			

Figure Two: The Review Matrix

Conclusions

The CDI committee's move to the web has enabled time taken to manage the paper production process to be dramatically reduced. The estimate of session organizers involved in the Munich Turbo Expo was that the prototype process, that was not web based, reduced session organizer workload by over 50%.

The process will be fully implemented and tested over the next year, during organization of the New Orleans Turbo Expo. The intent is to have a fully operational system in place by then.

We hope the development process of the CDI Committee web site will help reveal means for a more web-based paper review procedure. Once the CDI site is fully operational its design and structure might be helpful to other technical committees as well.

To conclude, the CDI Committee takes the view that the future is a web-based e-committee. This will more fully involve members, and dramatically reduce the time associated with the paper production process. The focus on "value added only" activity will make IGTI a more rewarding institution to be a part of, and will ensure that busy people still want to take the time to be a part of it. *





COMMUNICATION

E-COMMITTEE...continued

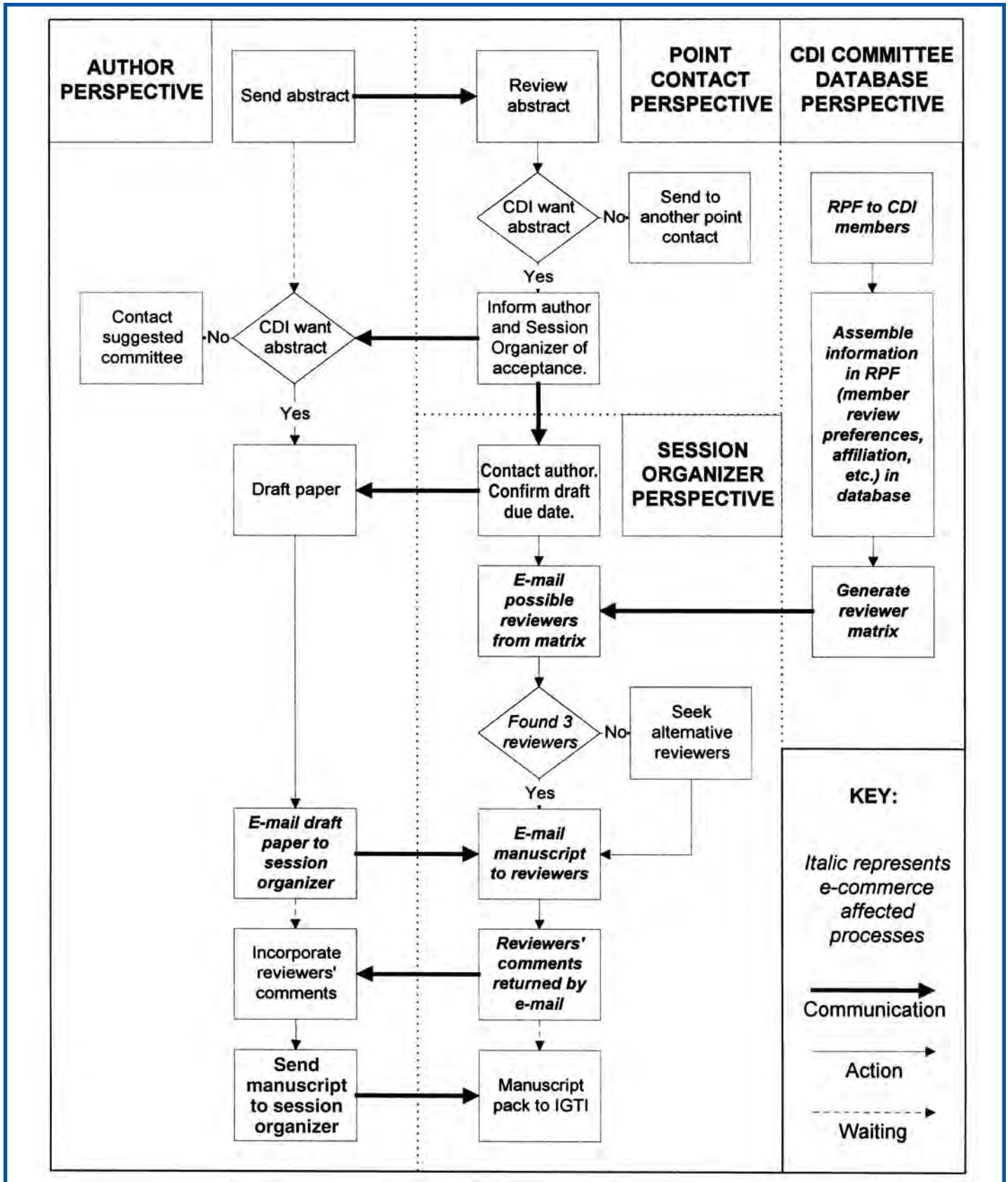


Figure Three: The IGTI "Paper Production" Business Process





ASME TURBO EXPO 2000...

CONFERENCE WRAP-UP

“Guten Tag”... from Munich ... the Heart of Bavaria

by David C. Wisler, IGTI Board Vice Chair

Local Liaison Committee Chair Broichhausen and ASME President Nickell welcome attendees at the historic “Residence.”



TURBO EXPO 2000, held in Munich Germany in May, continued the outstanding tradition of excellence that is synonymous with this event. This tradition of excellence has been brought about by the hard work of many, many people over the past few decades. It has led to ASME TURBO EXPO’s becoming the world’s finest technical meeting for the exchange of gas turbine science and technology, and a major focus for gas turbine users to meet and discuss issues. Everyone who has worked to make TURBO EXPO succeed can feel justifiably proud of its reputation. And this year’s event in Munich was no exception!

The Technical Congress, Users Symposium and Exposition attracted over 3,500 participants from 1,220 organizations and 60 countries around the world. There was something for everyone: 132 strong technical sessions with many excellent presentations, 23 user sessions with lively discussions on current issues, and an outstanding exhibit featuring the products and services of 198 companies. All of this plus keynote addresses, tutorial sessions, development courses, committee meetings, a wonderful welcome reception at the Residence, facility tours, events for spouses, fine food, and yes, beer—what more could one expect in Bavaria!

A strong and active Local Liaison Committee, chaired by Klaus Broichhausen of MTU, was a key element in achieving this success, assisted by

MTU München, Siemens AG Power Generation, Universität der Bundeswehr München, Daimler-Chrysler Aerospace, and Technische Universität München in sponsoring various aspects of TURBO EXPO.

Special Events

Three outstanding keynote speakers gave thought-provoking insights that addressed the Conference theme “Industry in Transition”. Norbert König, who is Member, Group Executive Management from Siemens AG Power Generation Group (KWU) gave an outstanding picture of the changes taking place in the power industry. Then Paul Grall, President & CEO of MTU—Maintenance, Hannover, provided an excellent overview of aeroengine technology. Following these presentations, Wolfgang H. Demisch, a leading financial analyst and managing director of Wasserstein Perella Securities, Inc. gave a lively

Exposition



Exposition

People’s Choice Award ... Small Display.



Dmitris Nikitopoulos (left) wins Palm VII at Thursday’s drawing.



Dave Wisler (2nd from right) presenting Local Liaison Committee with their Certificates of Appreciation. (L to R) Fottner, Taud, Schubert and Broichhausen. Kau and Kellner not shown.



Keynote Paul Grall, MTU-Maintenance, Hannover.



ASME TURBO EXPO 2000...

CONFERENCE WRAP-UP...continued

presentation that focused on the gas turbine industry from the perspective of Wall Street. The complete text of Mr. Demisch's presentation appears starting on page 8 of this newsletter.

The Grand Opening Reception/Lunch was held in the M,O,C, Exposition halls on Monday morning following the Keynote Session. This was very well received, and after lunch the congress participants visited the world's leading suppliers of gas turbines and associated equipment on the exhibit hall floor.

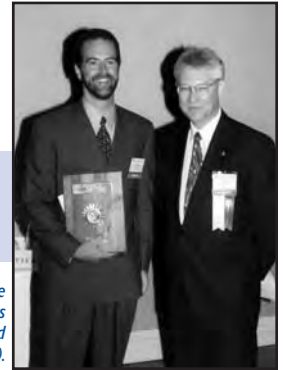
Later that evening, a wonderful reception was held in the Residence—a splendid hall in the Center of Munich. The artwork and décor were a magnificent reminder of Munich's heritage.

The Technical Congress, Users Symposium and Exposition

From a technological perspective, the Conference was brimming with technical sessions and panels. The IGTI committees did an outstanding job of getting 614 papers reviewed and organized into relevant categories. There were many favorable comments about the technical content of papers



Registration



ASME Gas Turbine Award winners Panovsky (L) and Kielb (R).

and authors' presentations this year. The time set aside for committee meetings allowed members to gather to discuss current topics and plan for next year.

From a user's perspective, the sessions in the Gas Turbine Users Symposium were very popular. They covered the two themes of business & operations issues and maintenance, repair and retrofitting issues. The Users Symposium has grown over the last five years to the point where it had a major focus and impact in Munich.

The Exhibit captured much attention during the Conference. It was a place to see and learn about new products and services, rendezvous with friends and new acquaintances and enjoy the busy atmosphere. The exhibitors did an outstanding job in answering questions and providing information. Our hats are off to them.

And finally, what would a great Conference be without the one-on-one private discussions being held in almost every corner of the hall. These were the places to iron out technical points, renew friendships, and catch up with what each other has been doing the past year.

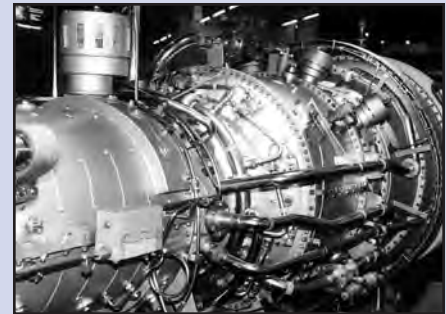
Keynoter Norbert König, Siemens AG



Aircraft Engine Technology Award winner, Peter C. Tramm (L).



Exposition



Keynote Session



People's Choice Award ... Large Display. Jim Flakus receives for Bently Nevada.



John P. Davis Award winner Jean-Pierre Stalder (R).



ASME TURBO EXPO 2000...

CONFERENCE WRAP-UP...continued

New This Year

CD ROM – a smashing success. This year all of the papers were available on CD, which incidentally were sold out on the second day of the Conference. Many favorable comments were heard throughout the hall.

User's Lite & Technical Lite Session—a new concept this year. The idea was simple—cross pollination. On the technical side, there were a large number of very knowledgeable experts in the technology of gas turbines at TURBO EXPO 2000. On the users' side, there were a growing number of very knowledgeable experts in the operation and maintenance of these machines. Two groups with diverse, but related, problems and perspectives. The User's Lite & Technical Lite Session was a start at bridging the gap between the groups. Each side built "Lite" presentations describing issues relevant to the other side. The users learned about rotating stall, film cooling and aeromechanics from the technologists and the technologists learned about maintenance and operational problems from the users. They were all in the same room, sharing ideas—imagine that!

Of Special Note

A number of important awards were presented at TURBO EXPO 2000. We offer our heartiest congratulations to all award recipients. For a brief summary, refer to the adjacent sidebar.

The list of people who brought about the success of TURBO EXPO 2000 is quite extensive, but most individuals easily fall into three major groupings. First are the IGTI Technical Committee Point Contacts. These great people, together with the growing number of Vanguard Chairs (for the larger Committees) and all the supporting session organizers, are real contributors to the success of the Congress. We appreciate your efforts.

Second, thanks to the members of the IGTI Board of Directors; the members of the IGTI staff in Atlanta, led by Ann McClure; the Technical Program Chair, Ray Chupp; the Gas Turbine Users Symposium Chair, Erio Benvenuti; and the Review Chair, Dilip Ballal. You were terrific.

And third, but by far the most important people on this list, are you and your colleagues ... our customers and exhibitors. Your conference attendance and participation on the exposition floor are at the heart of our efforts. We hope that you found TURBO EXPO 2000 to be beneficial. Please make plans now to attend ASME TURBO EXPO 2001 in New Orleans, Louisiana, USA, and recommend this Technical Congress, Exposition and Users Symposium to your friends and colleagues.

*If you missed this Conference in Munich, you missed an enriching and educational time. **



Exposition



Many thanks and congratulations to the recent award winners honored at ASME TURBO EXPO 2000. May your talents, commitment and perseverance continue to be rewarded throughout your careers.

2000 R. Tom Sawyer Award

Martin C. Hemsworth

1998 ASME Gas Turbine Award

Josef Panovsky • Robert E. Kielb

1998 John P. Davis Award

Jean-Pierre Stalder

2000 Aircraft Engine Technology Award

Peter C. Tramm

IGTI Beginning Engineer Fellowships

Rohit Oke • James Tallman • Xinwen Xiao

TURBO EXPO 2000 People's Choice Award for Large Display

Bently Nevada Corporation

TURBO EXPO 2000 People's Choice Award for Small Display

Southwest Research Institute



ASME TURBO EXPO 2000...

CONFERENCE WRAP-UP...continued

Martin C. Hemsworth Receives the ASME R. Tom Sawyer Award in Munich

The R. Tom Sawyer Award is bestowed upon an individual who has made important contributions to advance the purpose of the gas turbine industry and the International Gas Turbine Institute over a substantial period of time. The contribution may be in any area of Institute activity, but must be marked by sustained forthright efforts. First awarded in 1972, it is IGTI's highest award. Past recipients include: Sir Frank Whittle, Hans von Ohain, Noel Penny, Sven-Olof Kronogard, Anselm Franz, Ben Koff, Gerhard Neumann, and many other prominent individuals both inside and outside of IGTI.

Martin C. Hemsworth's innovative engineering excellence spans more than 50 years ... from the first jet engines of the early 1940s to the engines of the new millennium. He was the driving force for the development of the first high bypass turbofan engine, the TF39. The derivative of the TF39, the CF6, now powers the vast majority of the world's commercial aircraft.

Mr. Hemsworth received his Bachelor of Science in Mechanical Engineering from the University of Nebraska and joined the General Electric Company in 1940 as a design engineer of hot gas and altitude test facilities for turbo-superchargers and jet engines.

In 1951 he began project assignments in engine design, leading to his appointment as Manager of the Component Engineering Section. He was responsible for the design of all of GE's large jet engine components.

After a short stint as Manager of Engineering for Small Engines, Mr. Hemsworth became Manager of Engineering for GE's high bypass engines. For the TF39 a half-scale demonstrator was first developed, then a full-size version. The world's first large high bypass engine, the TF39 first flew in the U.S. Air Force's C5A in July 1968. The GE CF6 family of widely used commercial engines is derived from the TF39, as is the LM2500, a very successful 25,000 shaft horsepower non-aircraft derivative.

In 1971 Mr. Hemsworth was named Chief Engineer, GE Aircraft Engines. In 1976 he became Manager of the NASA/GE Energy Efficient Engine Program. Named again as Chief Engineer in 1980, he became Senior Consultant of Engine Design in 1985. In 1987 Mr. Hemsworth retired and now consults part time with GE.

Mr. Hemsworth holds 14 patents and has received the Ralph J. Cordiner Award (1963) and GE's Steinmetz Award (1977) for engineering excellence. In 1984 he received the Society of Automotive Engineers' Franklin W. Kolk Air Transportation Progress Award. His professional affiliations include the National Academy of Engineering (1980), Fellow of ASME, and member of the American Institute of Aeronautics and Astronautics. He is a member of Tau Beta Pi and Pi Tau Sigma honorary engineering fraternities; and when he retired in 1987, Mr. Hemsworth was elected to the GE Aircraft Engine Hall of Fame.

ASME, IGTI and representatives of the worldwide gas turbine industry were pleased to honor Mr. Hemsworth at the Awards Dinner on May 7 held at the Munich Park Hilton Hotel in conjunction with the opening of IGTI's TURBO EXPO 2000. *



The R. Tom Sawyer Award is presented to Martin C. Hemsworth (L) by ASME President Robert E. Nickell.

Contributors to Awards and Scholarships...

For the first time, in conjunction with TURBO EXPO 2000, IGTI provided an opportunity for industry personnel to contribute to the Awards and Scholarships Programs of the Institute.

The following generous contributors have kicked off this program, and we thank them for their support. Look for information in future issues of this newsletter as to how you too can contribute.

Alexandr Belokon ❖ James Carlyle ❖ Kamil Czwiertnia ❖ Mario DeCorso ❖ Howard Holland
Richard Roby ❖ Takayuki Sakai ❖ Dmitry Volkov ❖ Reinhard Willinger

"Big Easy" ...continued from front page

❖ A joint TE'01 / IJPGC Keynote Session with the theme, "New Horizons for Global Power ... Manufacturer-User Dialogue" will open the conference. To address this theme, we are proud to announce the participation of the following outstanding keynote speakers:

- Mr. Del Williamson, President, GE Power Systems Global Sales
- Mr. Randy Zwirn, President & CEO, Siemens Westinghouse Power Corporation
- Mr. Larry Izzo, President & CEO, Enron Engineering and Construction Company
- Mr. Ron McCarty, Director of Power, Champion Paper Company.

These speakers will present the views of buyers and sellers in the power generation arena. Over 1,000 delegates are expected to attend this Keynote Session, which features one of the most distinguished groups of keynoters ever assembled for an IGTI event!

❖ Mrs. Hanni von Ohain, wife of the late Dr. Hans von Ohain (co-inventor, with Sir Frank Whittle, of the jet engine), will be present to help cut the ribbon to open the world-renowned Exposition of gas turbine and other power generation products. In addition to the myriad of industry products and services on view during the Exposition, plans are underway for the 2001 Expo to include an historic display of the early gas turbines of Dr. von Ohain and Sir Frank Whittle.



Mrs. Hanni von Ohain

This year, in a National Academy of Engineering (NAE) poll, the engineering community in United States ranked Electrification and Airplanes as the first and third key inventions respec-

tively that contributed to the quality of life during the past 100 years. Today, gas turbines power both of these inventions, and the world market for gas turbine engines (about equally divided between electric power generation and aircraft engines) is projected to be over \$372 billion for the first decade of the 21st Century. Currently, the U.S. market is probably the hottest area for new machinery, with some remaining pent-up demand for power generation and with an aging commercial aircraft fleet being replaced by new aircraft with modern engines.

It has been said that every significant advance in gas turbine technology in the last 30 years was first presented at ASME TURBO EXPO, and this continues for 2001. At TE'01 the hot topics in gas turbine design, manufacturing, education, management, operation, repair and maintenance will all be discussed by the world's leading experts in a non-commercial open forum. More than 500 refereed papers, 20 panel sessions, 250 exhibiting companies and 4,500 industry experts will be there to help you find answers to your company's challenges. In the last issue of this newsletter, IGTI Board Chair Allan Kidd showed that "a conservative estimate of the return-on-investment (ROI) for the TURBO EXPO experience is 3 to 1." And that attendance benefit was calculated for an overseas event. For a domestic venue such as New Orleans, lower costs will translate into an even higher ROI. You and your colleagues need to be in New Orleans next June because attendance at ASME TURBO EXPO will be a worthwhile business investment for you and your company.

Between now and next June, many features of TE'01 will become finalized: registration and housing forms, guest activities, plant tours, short course and session schedules, social events, and much more. To keep up-to-date on any or all of these arrangements as they occur, visit the IGTI web site often at www.asme.org/igti/te2001/; or even better, go to this web page and click on "Subscribe to E-Bulletin" to get automatic email notification of new postings. IGTI wants to make it easy for you to visit the Big Easy! ❖

Distinguished Members of the ASME TURBO EXPO '01 Leadership Team are:

- Executive Conference Chair: Geoffrey D. Roberts, Jr., Entergy Wholesale Operations
- Chair of Conferences: Dilip R. Ballal, University of Dayton
- Review Chair: Ron A. Natole, Natole Turbine Enterprises, Inc.
- Technical Program Chair: Abbie W. Layne, National Energy Technology Laboratory, U.S. Department of Energy
- Gas Turbine Users Symposium Chair: Harold R. Simmons, Southwest Research Institute

Call For Papers: Final Reminder

ASME TURBO EXPO 2001
– Land, Sea & Air
4-7 June, 2001
(Exposition 4-6 June)
Ernest Morial Convention Center
New Orleans, Louisiana USA

Sponsored by: ASME International Gas Turbine Institute (IGTI)
Technical Program Chair: Abbie Layne, National Energy Technology Laboratory, DOE
3610 Collins Ferry Rd. MS CO2, Morgantown, WV 26505 USA
Phone: 1-304-285-4603, Fax: 1-304-285-4403, Email: abbie.layne@netl.doe.gov

A **SMETURBO EXPO** offers an unparalleled opportunity for practitioners in the gas turbine field to interface with experts from all facets of the business. Publishing work that advances the state of the industry is an excellent way to stimulate thought by others and to gain recognition for significant contributions to the application, design and operation of gas turbines.

Your colleagues at IGTI and in the entire gas turbine community encourage you to join with the more than 500 expected international presenters to participate in this unique forum. The Technical Committees of IGTI are developing sessions on topics related to applications, design, management, operation, and manufacture of all gas turbines and related equipment for the 46th annual ASME Gas Turbine and Aeroengine Technical Congress, Exposition & Users Symposium.

July 7 was the deadline for abstracts, but if you still want to have your research and experience considered for publication, contact the appropriate committee to see if late submittals are possible. If so, submit a 200 to 300 word abstract as soon as possible to the Point Contact or Vanguard Chair of the appropriate Technical Committee or to Abbie Layne, Program Chair. Provide all pertinent contact information, including address, phone, fax, and email. Be sure to visit our web site at www.asme.org/igti/te2001 and click on "call for papers" for additional deadlines and submittal instructions. Click on "point contacts" for detailed calls and contacts for IGTI's Technical Committees.

All paper submittals are interpreted as an intention to attend the conference (registration fee required) and to present the final paper. *

Global Gas Turbine News **READER SERVICE CARD**

MAIL, FAX or EMAIL TO: IGTI • Atlanta, GA • See Page 25 for details

- FOR ADDRESS CORRECTION:** Please check the box at left, and complete the form below with your current information.
- FOR INFORMATION:** Check the IGTI Web Site FIRST for items with (*). Otherwise, complete the return address information below, and check the appropriate boxes.

Name: _____ Job Title: _____
 Company / Institution: _____
 Street Address: _____ City: _____
 State / County: _____ Mail Code: _____ Country: _____
 Phone: _____ Fax: _____ E-Mail: _____

Check all for which you desire additional information:

- (1) IGTI Projects & Services*
 (2) ASME Membership*
 (3) Global Gas Turbine News Subscription Information*

ASME TURBO EXPO 2001 - New Orleans, LA (4-7 June)

- (4) (Also see articles in this newsletter)

HOME STUDY COURSE INFORMATION:

- (5) Basic Gas Turbine Engine Technology*
 (6) Design of Gas Turbine Engines—
 Thermodynamics and Aerodynamics*
 (7) Gas Turbine Applications and Economics*
 (8) Scholarships for ASME Student Sections*
 (9) Journal Subscription Subsidy for ASME (#22-IGTI) Members*
 (10) Journal Subscription Information for Others
 (11) 2000 IGTI Technology Report & Product Directory
 (prepay \$10.00 S&H)

- (12) IGTI Technical Committee Information*
 (Specify) _____

DIRECTORY OF TECHNICAL PAPERS from ASME TURBO EXPO, ETC.— Cost/Order Form:*

- (13) Vol. 1: 1957 - 1986
 (14) Vol. 2: 1987 - 1991
*Note that paper titles for 1990 thru 2000 (with ordering instructions) appear on the IGTI web site**
- (15) AGARD-AR-245 "Recommended Practices for Measurement of Gas Path Pressures and Temperatures for Performance Assessment of Aircraft Turbine Engine Components." Prepay \$25.00 to IGTI. (Includes S&H)
- (16) *The History of Aircraft Gas Turbine Engine Development in the United States* by James St. Peter. Order ONLY through ASME headquarters. (Book No.: 800970) \$55.00 ASME members; \$65 non-members; plus S&H*

COMMENTS/SUGGESTIONS: _____

2000, No. 2

For the most up-to-date information
***ALWAYS CHECK THE IGTI WEB SITE FIRST AT ... <http://www.asme.org/igti/>**
Downloadable Reader Service Card available for Emailing

Introducing

NEW IGTI TECHNICAL COMMITTEE CHAIRS

FOR THE 2000-2002 TERM



Before joining the U.S. Air Force Research Laboratory, Dr. MacArthur worked in mathematical modeling of various problems of aircraft safety at the University of Dayton. At AFRL he has performed and directed research and development in turbine heat transfer and aerodynamics for advanced military gas turbine engines. He is presently responsible for the strategic direction and quality of all in-house research conducted in the Turbine Engine Division.

Charlie and his wife Joanne constantly struggle with a few acres in Clayton, Ohio, where, when not "beating back the jungle," they enjoy reading, travel, and bird watching. Charlie has served on the Village Council and maintains an interest in local government. For frustration, Charlie attempts to keep a Ford 9N tractor running for "just one more year."



Charlie engaged in an extended conversation with his 16 month old granddaughter Hailey.

COMMITTEE: Heat Transfer

Charles D. MacArthur – "Charlie" (Joanne)
 Chief Scientist, Turbine Engine Division
 Propulsion Directorate
 U.S. Air Force Research Laboratory (AFRL)
 Dayton, Ohio USA
 Attended: Ohio State University
 University of Dayton
 Term: 2000 – 2002

Geoff has been involved in the gas turbine industry for twenty years, since he left school and joined the Rolls-Royce undergraduate training program. After completing a doctorate at Oxford University, Geoff worked for a number of small companies specializing in gas turbine instrumentation. He then joined Allen Steam Turbines as Chief Engineer. In his current role, Geoff is running the Rolls-Royce industrial gas turbines Whole Engine Group, and looking forward to completing his MBA at the end of this year. A regular attendee at TURBO EXPO since first publishing two papers at the Amsterdam

conference in 1988, Geoff has presented papers, organized sessions and more recently acted as Committee Vanguard Chair and point contact.

Geoff and Caroline have a seven year old son and four year old daughter. An interest in old buildings has kept Geoff busy for the past four years converting a set of Victorian barns on the grounds of a minor stately home into a family home. He has sworn to buy a new house next time!



COMMITTEE: Controls, Diagnostics & Instrumentation

Anthony G. Sheard – "Geoff" (Caroline)
 Chief of Whole Engine Integration
 and Modeling
 Rolls-Royce plc
 Ansty, Coventry UK
 Attended: Oxford University
 Term: 2000 – 2002



Relaxing on holiday in the Florida Keys with his wife Caroline.

TECHNICAL COMMITTEE CHAIRS

Term 2000-2002

Dr. Kenneth C. Hall received his degrees from the Department of Aeronautics and Astronautics at M.I.T. From 1987 to 1990, he was an Associate Research Engineer at the United Technologies Research Center. In 1990, he joined the faculty of Duke University. Professor Hall's research has focused primarily on computational unsteady aerodynamics, structural dynamics, aeroelasticity and aeroacoustics of turbomachinery and aerospace vehicles, but especially as related to turbomachinery.

Kenneth was a National Science Foundation Presidential Young Investigator from 1991 to 1997. Also, in 1986, he was the American co-winner of the Ernst Zimmermann Memorial Award, awarded to investigators under the age of 30 for contributions in the field of propulsion technology. He is a Fellow of ASME, an Associate Fellow of AIAA, and the recipient of the Structures and Dynamics Committee Best Paper Award for 1997.



Kenneth is an avid aviator. He earned his private pilot license for single engine airplanes in 1991 and now holds instrument, multiengine, and commercial pilot ratings. Two years ago, he satisfied a life-long dream to own an airplane when he purchased a 1978 Cessna 172N "Skyhawk." Kenneth has logged more than 600 hours of flying time.

Kenneth and his family (Janet and children David and Christine) on vacation in Sedona, AZ in 1999.



COMMITTEE: Structures and Dynamics

Kenneth C. Hall – (Janet)
Associate Professor
Duke University
Department of Mechanical Engineering
and Materials Science
Durham, North Carolina USA
Attended: Massachusetts Institute
of Technology
Term: 2000 – 2002



Stan came to the Lewis Research Center (now Glenn) in 1969 after completing his Ph. D. in Chemical Engineering. He is currently Ceramics Branch Chief. The branch consists of about twenty scientists and engineers from diverse disciplines who research structural and functional ceramic materials science with a focus on aircraft and spacecraft propulsion systems. For the past three years Stan's primary focus has been on structural ceramics for advanced space transportation systems. In the mid-1980s Stan led a high temperature coatings research group for about six years. He also performed research on metallic and ceramic coatings for refractory metals and superalloys. He has authored over 50 technical papers including a few book chapters and holds four patents.

Stan is married to Phyllis, an artist and avid gardener. Stan supports his wife's art by stretching canvasses and framing paintings. He supports the gardening activity by providing the heavy labor. They have lived in Ohio, within earshot of Lake Erie, for the past 28 years, and have four children: Emily, Lauren, Jessica, and Peter. They also have a Boston Terrier and a "Heinz" (57 varieties).

COMMITTEE: Ceramics

Stanley R. Levine – "Stan" (Phyllis)
Ceramics Branch Chief
NASA Glenn Research Center
Lewis Field
Cleveland, Ohio USA
Attended: City College of New York
City University of New York
Term: 2000 – 2002

Born and raised in Brooklyn, New York, Stan has been a life-long saltwater (and occasional fresh water) fisherman, but doesn't get many opportunities. He says the results depicted here are not typical.



TECHNICAL COMMITTEE CHAIRS

Term 2000-2002



Jeff has been employed by the Naval Surface Warfare Center, Carderock Division - Ship Systems Engineering Station (NSWCCD-SSES), since 1987. He holds a B.S. degree in Mechanical Engineering from Drexel University (1984) and an M.S. degree in Engineering Management from Widener University (1994). He has been in his current position, as supervisor of the Gas Turbine Emerging Technologies Section since September 1997. While at NSWCCD-SSES, Jeff has worked exclusively on marine gas turbine engines and their related support systems.

An active member of the IGTI Marine Committee for the past eight years, Jeff has filled a number of roles, including author and presenter, technical session organizer, meeting organizer and Committee Secretary and Vice Chair.

In his free time, Jeff enjoys golf, weight lifting, woodworking and vacationing at the shore in southern New Jersey. However, he and his wife Rose have been very busy lately, taking care of their newborn daughter, Gianna Marie. Born on May 10, 2000, she is Jeff and Rose's first child and the apple of her daddy's eye.



Jeff and Gianna Marie spending some quality time together, following her late evening feeding.

COMMITTEE: Marine

Jeffrey S. Patterson – "Jeff" (Rose)
Supervisor, Gas Turbine Emerging
Technologies Section
Naval Surface Warfare Center
Philadelphia, Pennsylvania USA
Attended: Drexel University
Widener University
Term: 2000 – 2002

Most of Hal's career has been spent in engineering education. He joined Arizona State University as a full-time faculty member in 1967 and served continuously in its Mechanical & Aerospace Engineering Department. In 1991 Hal joined Texas Christian University as Founding Chair of their new Department of Engineering. After the engineering program at TCU was ABET accredited in 1997, he rejoined ASU as an Adjunct Professor. Hal also assumed the editorship for the ASME Journal of Engineering for Gas Turbines and Power.

Early in his career, Hal worked for Eastman Kodak as a design and development engineer on cameras and projectors, and later as a consultant for Honeywell Engine Company in Phoenix, Arizona. Most of his consultation involved the development of rotordynamics software programs for use in the design and development of gas turbine engines.



Although officially retired, Hal continues to teach part-time at ASU. Most of his spare time is spent working at home or on improving his golf game on the numerous outdoor "spheroidal dynamics laboratories" in Arizona. Hal's wife, Connie, teaches pre-school and coordinates family activities. Five of their six children, and eight grandchildren, live in the Phoenix area. Another married son lives and works in Monterrey, Mexico.



Harold and wife Connie in Toronto.

COMMITTEE: Education

Harold D. Nelson – "Hal" (Connie)
Adjunct Professor, Mechanical &
Aerospace Engineering Dept.
Arizona State University
Tempe, Arizona USA
Attended: South Dakota Tech, Kansas
State University, and
Arizona State University
Term: 2000 – 2002

N O M I N A T I O N S S O L I C I T E D

IGTI Aircraft Engine Technology Award

- Nominations are being solicited for worthy candidates in anticipation of bestowing the award for the tenth time — June 2001, at TE'01 in New Orleans, Louisiana.
- The award will be made for sustained personal creative contributions to aircraft gas turbine engine technology in the areas of aircraft engine design and/or research and development performed in an industrial, academic or research laboratory environment in the fields of:
 - turbomachinery
 - combustion and fuels
 - heat transfer
 - manufacturing materials and metallurgy
 - structures and dynamics
 - controls and diagnostics or
 - integration
- The award will include the opportunity to deliver a lecture on the work for which the award is being bestowed, at the Technical Congress in June 2001.
- The recipient of the award will desirably, but not necessarily, be a member of The American Society of Mechanical Engineers. **The award will be made to a single individual.**

Nominating Letters should be sent by August 31, 2000 to:

Theodore E. Elsasser
 Chair, Aircraft Engine Technology Award Committee
 110 Kings Place
 Tullahoma, TN 37388 USA
 Phone: 1-931-455-6390
 Email: telsasser@cafes.net

- Nominating letters should contain all information on the nominee's relevant qualifications.
- Accompanying the nominating letter must be a minimum of two supporting letters from individuals other than the nominator. Supporting letters should reflect peer recognition of the nominee's breadth of experience with various aspects of aircraft engine technology.

Past recipients of the IGTI Aircraft Engine Technology Award are:

1992
Dr. Leroy H. Smith

1993
Dr. Christos Chamis

1994
Dr. Ernst R.G. Eckert

1995
Dr. Edward M. Greitzer

1996
Dr. Arthur H. Lefebvre

1997
Dr. Budugur Lakshminarayana

1998
Dr. John Denton

1999
Dr. Louis A. Povinelli

2000
Mr. Peter C. Tramm



©2000 ASME International Gas Turbine Institute. Printed in U.S.A.

Published by the International Gas Turbine Institute
 The American Society of Mechanical Engineers
 5775-B Glenridge Drive, Suite 370, Atlanta, Georgia 30328-5380 USA
 Phone: 01 (404) 847-0072
 Fax: 01 (404) 847-0151 or 01 (404) 843-2517
 E-Mail: lindsayd@asme.org • Web Site: <http://www.asme.org/igti/>

EDITORIAL ADVISORY BOARD

David C. Wisler, Chair Ron A. Natole
 Dilip R. Ballal Erio Benvenuti

STAFF EDITOR

David H. Lindsay, IGTI, Atlanta, Georgia



INTERNATIONAL GAS TURBINE INSTITUTE

2000 - 2001 BOARD OF DIRECTORS

ASME VICE PRESIDENT - IGTI
 CAROL J. RUSSO
 NASA Glenn Research Center

CHAIR
 ROBERT E. KIELB
 GE Aircraft Engines

VICE CHAIR
 DAVID C. WISLER
 GE Aircraft Engines

PAST CHAIR
 H. ALLAN KIDD
 Dresser-Rand Co.

TREASURER
 GEORGE OPDYKE, JR.
 Dykewood Enterprises

CHAIR OF CONFERENCES
 DILIP R. BALLAL
 University of Dayton

MEMBER-AT-LARGE
 TORSTEN H. FRANSSON
 Royal Institute of Technology

MANAGING DIRECTOR
 ANN E. McCLURE
 International Gas Turbine Institute

REVIEW CHAIR
 RON A. NATOLE
 Natole Turbine Enterprises

MEMBER-AT-LARGE
 HOWARD W. HOLLAND
 Enron Engineering & Construction

INCOMING MEMBER
 ERIO BENVENUTI
 Nuovo Pignone S.P.A.

MISSION STATEMENT

The International Gas Turbine Institute of The American Society of Mechanical Engineers is dedicated to providing international forums for the exchange and development of information to improve the design, manufacture, operation and application of all types of gas turbines and related equipment.



World Gas Turbine Industry Production Trends and Key Factors – 2000-2009

33 Page Report

Price: \$125.00

In response to industry demand, and in cooperation with Forecast International/DMS, the IGTI Board of Directors is pleased to announce the availability of the above gas turbine industry forecast. The report was prepared by the Forecast International Power Group for the IGTI Board of Directors in preparation for ASME TURBO EXPO 2000 in Munich, Germany. The data used to prepare the report were effective as of April 17, 2000, and were drawn directly from the company's *Gas Turbine Forecast* service, as well as from associated databases and other sources.

Table of Contents:

Format
Executive Summary and Market Overview
World Gas Turbine Industry 2000-2009
Market Shares of Industry Participants
General Industry Information
Aero Engines
Gas Turbines Used to Power Manned Aircraft
Key Factors/Trends, Aero Engines
Industrial & Marine Gas Turbine Engines
Breakdown by Power Band
Key Factors/Trends: Power Generation Market
Key Factors/Trends: Mechanical Drive Gas Turbines
Key Factors/Trends: Marine Propulsion Systems
Miscellaneous Applications Engines
Key Factors/Trends: Missile/Drone/RPV/UAV Gas Turbine Engines
Key Factors/Trends: Auxiliary Power Units/Ground Power Units
Vehicular Propulsion/Rail Traction Turbines
Appendix
Charts and Diagrams

To order your report directly from Forecast International, contact:

Forecast International/DMS – Sales (Code: GGTN)

22 Commerce Road, Newtown, CT 06470 USA

Phone: (203) 270-0633 Worldwide

Phone: (800) 451-4975 in U.S. & Canada

Fax: (203) 426-0223 • E-mail: sales@forecast1.com

**Note: When ordering, always mention
"Code: GGTN"**

Disclaimer: ASME and IGTI are not involved in the development of the above report, and are not responsible for the content. Contact Forecast International/DMS for a separate warranty statement.



Frank Carta

Obituary and Eulogy for Franklin O. Carta

by Walter O'Brien, Virginia Tech

Franklin O. Carta, 69, died June 5, 2000, following an extended illness. Frank was an outstanding contributor to IGTI and the Gas Turbine Division, and a good friend to the membership. He was retired from United Technologies Research Center (UTRC) in Hartford, Connecticut. During his 40-year tenure with UTRC, Frank made many important technical contributions to his employer, and to the turbomachinery aeromechanics community. Frank held several patents, and authored more than 80 reports and papers. He received The American Society of Mechanical Engineers' ASME Gas Turbine (Best Paper) Award in 1967. He served as Chair of the Structures and Dynamics Technical Committee, Chair of the IGTI Board of Directors (1988-89), and ASME Vice-President-IGTI from 1992-94. He was a Fellow of ASME, and an Associate Fellow of the American Institute of Aeronautics and Astronautics.

I remember Frank for his technical expertise that he shared freely with specialists, students and anyone he could help. An outstanding researcher, he was also an enthusiastic teacher and speaker, and gave talks and lectures at many

universities, companies and technical meetings. He loved students and anyone who was interested in gas turbine engineering. He visited Virginia Tech on several occasions, and one could tell that his special interest was in students who wanted to discuss aeromechanics.

His smile and wit are well remembered by all of us who were privileged to know him. My special recollection is of an excellent bridge game which Frank and my wife Nancy led while waiting for a delayed flight to an IGTI conference in Europe. Frank's good humor helped everyone endure the wait, which eventually stretched to 3:00 am. It was characteristic of this gentleman to engage people in the most congenial and pleasant way, and to turn difficulty into a positive experience. Frank had many other interests, including skiing, gardening, music and historical restoration. After a good day's work, he loved good fellowship and good cuisine. He was a loving and proud husband and father.

IGTI, the field of turbomachinery aeromechanics, and the world are better because of the life of Frank Carta. It is a pleasure to share these memories of my fortunate association with him. *

“
**His smile and
wit are well
remembered
by all of us
who were
privileged to
know him.**
”

Available for Immediate Delivery—

The History of Aircraft Gas Turbine Engine Development in the United States ... A Tradition of Excellence

by James St. Peter

This absorbing, anecdotal history of gas turbine engine development spans over 50 years of scientific discovery, corporate intrigue, and insight into the minds of the historic personalities who shaped one of the great inventions of the 20th Century.

About the Book.

From the technological beginnings in England and Germany, through the proliferation of research and development in the United States, through the Great Engine Wars and the development of Mach 3 and stealth aircraft, to the modern IHPTET programs, this history draws upon the remembrances of those involved and a multitude of research sources that are quickly disappearing.

Included in the 600-page, hard-cover history are 19 chapters and 69 engine addenda, plus hundreds of photographs and illustrations, engine specifications and performance ratings, complete chapter endnotes, and a comprehensive index... ideal for reading, reference or continuing research.



About the Author.

James St. Peter is a Technical Historian contracted by the Air Force to research and write this historical look into the development of aircraft gas turbine engines in the United States. He was ideally suited for this landmark project because of his in-depth knowledge of jet engines and previous research experience.

St. Peter was selected by the Air Force Wright Laboratory, Aero Propulsion & Power Directorate, at Wright-Patterson Air Force Base in Dayton, Ohio. The effort was co-sponsored and financially supported by the Army, Navy, Air Force, NASA, and the ASME International Gas Turbine Institute.



Easy to Order...

* **ORDER ON-LINE FROM ASME'S CATALOG—**
<http://www.asme.org/catalog/>

Select the following 3 Search Categories to find this book.

Keyword(s): **800970**

Search by: **ASME order#**

Section: **Entire Catalog**

* Order by Phone

In the United States and Canada, call:

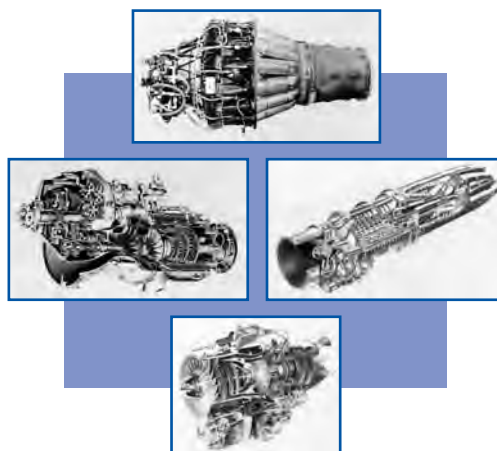
1-800-THE-ASME

Elsewhere, dial: **+1 (973) 882-1167**

Refer to ASME **Book #800970** when ordering from the Publications Center.

ASME Member Price: \$55.00

Non-Member Price: \$65.00





Jim Peters

James E. Peters (1954-2000)

Chair, IGTI Combustion and Fuels Committee

Remembrances by Dilip Ballal, University of Dayton, and Others

Professor James E. Peters, Chair, Combustion and Fuels Committee, an associate editor of the ASME Journal of Engineering for Gas Turbines and Power, and a Fellow of ASME, died on May 30 in a tragic auto accident in Champaign, Illinois. Jim was an associate head for undergraduate programs and director of the automotive laboratory in the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign (UIUC). He received his Ph.D. in 1981 from Purdue University. Our thoughts and prayers are with his wife Teresa and their two children, Anna (13) and Sam (8).

I was privileged to know Jim and thought of him fondly on both a personal and a professional level. He was a doctoral student during the late-'70s when I visited Purdue on my sabbatical leave from Cranfield University, England. Our mutual love of motorbikes and sports cars soon made us life-long friends. Jim was a tireless volunteer for ASME. He was a co-lecturer on the ASME-IGTI short course, "Combustor Modifications for Low Emissions," for four continuous years. Jim was a distinguished combustion researcher and authored more than ninety papers in two-phase flows, liquid spray behavior, alternative fuels, and particulate emissions in gas turbine and spark ignition engines. He served as Chair, Board of Directors of the Central States Section of the Combustion Institute. Not only I, but also the entire IGTI community has lost a great friend and a dedicated volunteer in Jim Peters.

Professor Richard Backius, head of Jim's department at UIUC states, "Jim joined UIUC as an assistant professor and rose through the ranks to become a full professor in 1991. Jim had been selected as the first James W. Bayne Professor at the time of his passing and UIUC awarded him this prestigious honor posthumously. Professor Peters was a superb teacher and won the Society of Automotive Engineers' (SAE) Teetor Award and the UIUC College of Engineering Everitt Award for teaching."

One of Jim's mentors from Purdue recalls, "Some years ago, I was given the responsibility for organizing an IGTI technical session. Close to the deadline date, it became apparent that three of the papers were going to be one review short, so I

wrote to three people, including Jim, asking them to provide me with a review within a week. Unfortunately, all three papers were placed in the same envelope, the one addressed to Jim. Most people would have returned them to me along with a few well-deserved rude comments, but that was not Jim's way. Within a week, reviews of all three papers were back on my desk, all carried out to Jim's high professional standards. This illustrates the selfless manner in which Jim was always ready and willing to help the cause of his profession."

Above all, Jim's students, friends and professional colleagues will remember his warm and friendly demeanor, his ready smile and his great sense of humor. Professor Mac Mellor, Jim's Ph.D. advisor at Purdue and another long-time mentor, recalls, "When Jim was an undergraduate, twice he came close to choosing a career in a discipline other than combustion, such as biomechanics. When I learned of this desire, no doubt my facial expression gave away my disappointment. Fortunately, at our next meeting, he informed me that his intention was to conduct two research projects: one in gas turbine combustion and the other in biomechanics, simultaneously. Thus continued a distinguished career in gas turbine combustion, cut short after only twenty-five years. I cannot express adequately my sense of deep personal loss."

Nor can any of us ... *



Jim receiving his Technical Committee Chair Certificate from Dave Wisler in Munich.

“
I cannot express adequately my sense of deep personal loss.
”

Journal of Turbomachinery

Important News from Ted Okiishi, Technical Editor

Scanning this brief article will help you:

1. Learn how to subscribe to the Journal of Turbomachinery at a substantial discount per year.
2. Find out more about electronic on-line versions of the journal.
3. Know who the newest associate technical editors of the journal are.
4. Hear some good news about the paper backlog.
5. Weigh in with your opinions about how to improve the journal.

1 For several years, IGTI has subsidized the annual subscription by ASME members who specify IGTI as their primary technology to either the Journal of Turbomachinery (TURBO) or the Journal of Engineering for Gas Turbines and Power (POWER). However, after listening to several members of the Turbomachinery Committee in Munich at TURBO EXPO 2000, I understand that what was meant to be easy, generous and useful works most of the time but fails sometimes.

So here is the deal. This offer does not include any international postage surcharges. As of July 1 this year, the regular annual subscription rate for ASME members for which the U.S. postage rate applies is \$50. With the IGTI subsidy, this \$50 rate is reduced to \$15. The international postage surcharge of \$35 (TURBO) or \$40 (POWER) for those residing outside the range of U.S. postage is **not** included in the subsidy. So for these individuals, the subsidized annual subscription rate is \$50 or \$55. I believe that for both domestic and international subscribers, these subsidized subscription rates are very low for the value received, a bargain.

To get this offer, you must be an ASME member who has selected #22 (IGTI) as your primary area of interest, and you must send your subscription request (including renewals) to the attention of one person only in ASME:

Ms. Marni Rice
Circulation Coordinator
ASME International
Three Park Avenue, 21E1
New York, NY 10016-5990

Marni's e-mail address is RiceM@asme.org If you feel you have not been able to benefit from this offer in the recent past, please communicate your concern to her.

2 ASME is offering electronic on-line versions of its journals including the Journal of Turbomachinery. To learn more about this go to <http://ojps.aip.org/ASMEJournals/Turbomachinery/> and click on to the different options available.

Journal subscribers will have access to their 2000 and later journals on line. Whether or not back issues will also be available this way has not yet been decided.



Ted Okiishi

3 The newest associate technical editors of the Journal of Turbomachinery are:

Roger Davis of United Technologies
Research Center
Computer Fluid Dynamics
davisrl@utrc.utc.com

Curt Koch of GE Aircraft Engines
Compressors
Curtis.Koch@ae.ge.com

Steen Sjolander of Carleton University
Turbines
sjoland@mae.carleton.ca

These well-qualified associate technical editors will help us be more responsive to authors submitting papers directly to the journal.

4 Papers presented at TURBO EXPO 2000 in Munich will begin showing up in the October 2000 issue of the journal. Most of them will have been published by the July 2001 issue. The time to publication has been reduced considerably from what it was just a few years ago.

5 If any of you have ideas for improving the journal, please pass them on to me at tedo@iastate.edu I welcome your comments. Also, I urge all of us to consider writing "discussions" of already published or to-be-published journal papers and to author technical briefs in addition to technical papers. These forms of technical communication are currently underutilized. *



“
This course gives a good general understanding of gas turbines in an easy-to-read format.
”

Mark Wolfanger,
Engineering Technician,
Dresser-Rand/Alfred State College

“BASIC GAS TURBINE ENGINE TECHNOLOGY”

Second Edition

This home Study Course is a 162 page non-mathematical approach to understanding the fundamental nature of gas turbine engines and the processes which affect their performance. The Course is ideally suited to technicians and management personnel. It will also prove to be of value to those engineers starting their careers in the fields of gas turbine engine and auxiliary equipment operation, maintenance or service, specification, sales and manufacture.

Introduced in 1985, more than 4,000 orders for “Basic Gas Turbine Engine Technology” have been received from industry personnel throughout the world. Here is a sample of comments from some of those completing the course:

“Excellent introductory course that maintains your interest throughout.”

William G. Machingo, Staff Engineer, Wright Patterson AFB.

“Initially we put one trainee on the Course and found it to be a good indoctrination to the world of gas turbines... we have now put several key personnel, including our Managing Director, through the Course.”

Timothy A. Trott, Operations Manager, Maghraby Limited.

Course Content

The Course is organized into ten chapters. Following each chapter when you are ready, you will take a test on that material. Take your time in answering the questions and feel free to double check by referring to the text material. When you are satisfied, send the completed tests to the International Gas Turbine Institute in Atlanta for scoring. Your corrected answer sheets will be returned for your information and review. When you have finished the the entire Course, you will receive a Certificate of Completion.

The cost of \$145.00 U.S. includes the text, grading and return of exam questions, and issuance of your Certificate of Completion. A special discount price of \$95.00 U.S. is available to qualifying students. *

“THE DESIGN OF GAS TURBINE ENGINES—Thermodynamics & Aerodynamics”

Second Edition

This Home Study Course introduces you to the fundamental principles for thermodynamic analysis and design of gas turbine components and systems, with insight into design practice. Selected gas turbine hardware is illustrated and described in the accompanying videotape. A companion personal computer program facilitates investigation of the effects of chosen design parameters on performance. This Course is intended for graduate engineers with a knowledge of thermodynamics and an interest in design analysis and performance prediction of gas turbines and components.

Course Content

This 445 page Course consists of 13 chapters and 8 appendices conveniently arranged in one 3-ring binder.

At the end of each chapter is a test that will help you measure your understanding of the content and your ability to work related problems. Test sheets contain multiple choices for ease of scoring by IGTI; however, when your scored answer sheet is returned, it will be accompanied by a detailed solution to each problem and an explanation of answers to other questions.

THE VIDEOTAPE: The two-hour videotape in for VHS cassette players and is available in either NTSC (U.S.) or PAL (European) format. When ordering, be certain to specify which format you require.

THE COMPUTER PROGRAMS: With this Course you receive software programs with which you can calculate the performance of both simple and fairly complex cycles. Programs may be run on most IBM or IBM compatible equipment. They are designed for immediate use and do not require a compiler or a math coprocessor.

The cost of \$345.00 U.S. for the Course includes the text, videotape, computer diskette(s), scoring and return of exam questions and answer sheets, and issuance of a Certificate of Completion. A special discount price of \$225.00 U.S. is available to qualifying students. *

“A great course for turbine operators!”

Arthur Hamilton, Watch Supervisor, Pawtucket Power

“GAS TURBINE APPLICATIONS & ECONOMICS”

If you are involved in the application of gas turbines in such diverse fields as power generation, auxiliary power systems, and cogeneration, or would like to understand more about the design and performance of gas turbine power systems, this course is for you.

Course Content

Performance is the key to application decisions involving gas turbines, and this course begins with a review of the thermodynamic principles for the prediction of performance of several gas turbine types. The involved processes are described, from simple gas turbine cycles, to complex regenerative and cogeneration cycles. Many example calculations are included, and preferred cycles for several different applications are described.

Performance includes economic optimization as well as efficiency, power output, and emissions control; and the course includes an economic optimization method based on an objective equation. Combustion emission laws and methods of compliance are discussed. A computer program, GTSHAFT, on disk is included with the course for the parametric analysis and optimization of gas turbine systems design. The GTSHAFT program includes both the executable files and the source code for convenient student use.

The 228 page Course is divided into nine chapters, and includes discussions of designs and performance calculations, many worked examples, and actual case studies of successful applications. Self-testing exercises, which will be corrected by IGTI, are included.

The cost of \$215.00 U.S. includes the text, computer diskette, scoring and return of exam questions, and issuance of a Certificate of Completion. A special discount price of \$140.00 U.S. is available to qualifying students. *

“
Excellent review of cycle thermodynamics and performance analysis for engineers involved in unit selection for electric power applications.
”

Albert Taylor, Senior Engineer,
R.W. Beck, Inc.





HOME STUDY COURSES

ORDER YOURS TODAY!

HOME STUDY COURSE ORDER FORM

ORDER INSTRUCTIONS:

1. Complete shipping address information (No P.O. Box addresses, *please!*).
2. Complete price information for relevant courses (*include taxes and/or shipping and handling costs per instructions*). Duty on non-U.S. shipments is the responsibility of the purchaser.
3. Complete payment information as appropriate. Checks payable to IGTI. **Must be in U.S. dollars and drawn on a U.S. bank.** (*Sorry, no wire transfers.*)
4. Fax (*with credit card information*) to (01) (404) 847-0151; or mail (*with other form of payment*) to:
IGTI • 5775-B Glenridge Drive, Suite 370, Atlanta, GA 30328 U.S.A.

SHIPPING ADDRESS:

Date: _____
 Name: _____
 Title: _____
 Company: _____
 Street Address: (No P.O. Box) _____
 Check One: Home Office

METHOD OF PAYMENT: (please check one)

- Check or Money Order in U.S. FUNDS ONLY (*Attach*)
 Credit Card - Please charge to my:
 VISA Master Card American Express Discover

Expiration Date: _____

Card Number: _____

Name of Cardholder: _____

Cardholder Signature: _____

City: _____ State: _____

Zip/Mail Code: _____ Country: _____

Phone: _____ Fax: _____

FULL-TIME STUDENTS* (if applying for student rate):

School: _____

Student Number: _____

"BASIC" COURSE	X	QUANTITY	=	COST
<input type="checkbox"/> Standard Rate \$145.00 U.S.	X	_____	=	_____
<input type="checkbox"/> Student Rate \$95.00 U.S. (full-time students only)*	X	_____	=	_____
+ Shipping & Handling (add \$15.00 each in U.S.; \$40.00 each outside U.S.)			=	_____
+ Taxes (CA, GA, IL, TX and D.C. must add the appropriate state and local sales taxes or furnish an exemption certificate. Purchasers in Canada should add 7% "Goods & Services Tax" or provide a Goods & Services Tax Number if exempt from tax.)			=	_____
"BASIC" COURSE TOTAL			=	_____

"APPLICATIONS" COURSE	X	QUANTITY	=	COST
<input type="checkbox"/> Standard Rate \$215.00 U.S.	X	_____	=	_____
<input type="checkbox"/> Student Rate \$140.00 U.S. (full-time students only)*	X	_____	=	_____
+ Shipping & Handling (add \$15.00 each in U.S.; \$40.00 each outside U.S.)			=	_____
+ Taxes (CA, GA, IL, TX and D.C. must add the appropriate state and local sales taxes or furnish an exemption certificate. Purchasers in Canada should add 7% "Goods & Services Tax" or provide a Goods & Services Tax Number if exempt from tax.)			=	_____
"APPLICATIONS" COURSE TOTAL			=	_____

NOTE: When ordering "APPLICATIONS" Course please check one of the following to specify type of Computer Diskette:
 3.5" DS-DD 3.5" HD

"DESIGN" COURSE	X	QUANTITY	=	COST
<input type="checkbox"/> Standard Rate \$345.00 U.S.	X	_____	=	_____
<input type="checkbox"/> Student Rate \$225.00 U.S. (full-time students only)*	X	_____	=	_____
+ Shipping & Handling (add \$20.00 each in U.S.; \$55.00 each outside U.S.)			=	_____
+ Taxes (CA, GA, IL, TX and D.C. must add the appropriate state and local sales taxes or furnish an exemption certificate. Purchasers in Canada should add 7% "Goods & Services Tax" or provide a Goods & Services Tax Number if exempt from tax.)			=	_____
"DESIGN" COURSE TOTAL			=	_____

NOTE: When ordering "DESIGN" Course please check one of the following to specify type of Computer Diskette:
 3.5" DS-DD 3.5" HD

NOTE: When ordering "DESIGN" Course please check one of the following to specify type of Video Tape:
 VHS/NTSC (U.S.) VHS/PAL (Europe)

*Student rate also applies if this home study course is used as part of a for-credit college curriculum.

For Tables of Contents, and downloadable Order Form, refer to our web site at
<http://www.asme.org/igti/>

Erio Benvenuti Joins IGTI Board of Directors as Incoming Member

Term: July 1, 2000 – June 30, 2001

Erio joined Nuovo Pignone in 1965 after graduation in Mechanical Engineering from the University of Bologna in Italy. His first assignment was in the centrifugal compressor department, where he worked in the development of very high pressure centrifugal compressor technology. After passing to the R&D department, he was appointed leader of a major development program to establish new innovative centrifugal compressor design techniques based on innovative tools, with support from an extensive experimental program lasting several years.

In the late '70s, when his company started the development of small-medium size gas turbines used mainly as compressor drivers, Erio established and led a new aerodynamic design group that significantly contributed to the success of a complete engine line ranging from 2 to 30 MW. His wide experience gained in compressor and gas turbine design is presently supporting the Nuovo Pignone Global Services Division, where he holds the position of Manager, Advanced Technologies. His main task is to leverage advanced design techniques to provide high



Erio Benvenuti

added value to service offerings in the areas of machine diagnostics, parts life management, reliability, retrofittings and upgrades.

Erio has written several tens of papers on compressor and gas turbine technology, and served as IGTI Gas Turbine Users Symposium Chair for TURBO EXPO 2000 in Munich. Recently he has been elevated to the grade of ASME Fellow. He likes to work in stimulating environments and to undergo new and sometimes challenging tasks, offering him opportunities for traveling and sharing experience with highly professional people around the world.

As Incoming Board Member, Erio will attend and participate in all Board meetings, but will not have a vote until he becomes a full Board Member as of July 1, 2001. According to the normal progression of offices, he will become Board Chair July 1, 2004 and will complete his commitment to IGTI Board service on June 30, 2006. We applaud Erio's dedication and commitment to the goals of IGTI, and are pleased to welcome him as Incoming Member of the IGTI Board of Directors. *



We applaud Erio's dedication and commitment to the goals of IGTI, and are pleased to welcome him as Incoming Member of the IGTI Board of Directors.



INTERNATIONAL GAS TURBINE INSTITUTE

The AMERICAN SOCIETY of MECHANICAL ENGINEERS

5775-B Glenridge Drive, Suite 370
Atlanta, GA 30328 USA

NON-PROFIT
ORGANIZATION
U.S. POSTAGE
PAID
ATLANTA, GEORGIA
PERMIT NO. 2685