

## Pryometer: Saving Energy In a Colorful Way

by Phyllis Rieger

When does the color red signify cold and the color blue mean hot? When you're using a boiler imaging pyrometer system for fossil fuel power plants.

It's a mouthful to say, but this system, recently developed by PPPL engineers, will measure temperatures of flames in coal-burning power plants. This is accomplished using a telescope-periscope containing a remotely controlled iris to monitor the flames and map their heat intensity. A television picture, a false color display color-coded to show the temperature gradients in the flame, would be viewed by a boiler plant operator. Using a computer and special software developed by PPPL, the operator would then adjust the the fuel

and oxygen, making sure that one flame isn't burning too hot and another too cold. There's an eight-color spectrum ranging from red which signifies cold, to blue which is the hottest. All this fine-tuning means energy saved.

According to PPPL engineer George Renda, "We began devising this system after several meetings between PPPL and staff researchers at Public Service Gas and Electric (PSE&G) Corporation held to identify areas where technology developed for fusion research might be useful to improve the performance of existing coal-fired power plants."

Over the past 30 years PPPL has developed diverse and unique engineering capabilities to meet the scientific and tech-

nical challenges of fusion energy research. The Laboratory is diversifying its program by developing projects in both the public and private sectors in which the Laboratory's technological resources and, in particular, the outstanding skills of the PPPL engineering professional staff can be applied. This promotes the transfer of technology and expertise developed under the fusion research program.

George Renda explained, "PPPL uses image sensor television cameras to monitor the plasma position in tokamak vacuum vessels, so we based our pyrometer on a similar premise. We began exploring the possibility of using a similar television camera with digital image processing to measure temperature gradients in the multiburner flames of a power plant boiler."

A feasibility study, conducted at PSE&G's Mercer Power Plant on Duck Island in Trenton, showed that the engineers were on the right track. George along with technical associate Greg LeMunyan began designing the pyrometer and its imaging system. Greg handled the electrical and software design while George served as program manager and systems engineer, with Bob Hoch responsible for mechanical detail engineering. PPPL engineers Steve Hayes and Don Long were brought in to consult on various areas of the system.

"We had to keep in mind that the pyrometer would be measuring flames between 2000-4000° F which meant we also had to design protection for the optics, so they wouldn't be damaged," said George. The entire pyrometer system sits on a tabletop and is about 12" wide, and 40" long, weighing about 60 lbs. It's not very impressive to someone unfamiliar



*Meeting to discuss the pyrometer's performance were: (l to r) PPPL's Greg LeMunyan, PSE&G's Dr. Melvin Zwillenberg, PPPL's George Renda and Bob Hoch.*

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with imaging systems, but PSE&G's Melvin Zwillenberg, principal staff engineer-research, who attended an unveiling of the pyrometer system on October 25 was very pleased with its performance, according to George. "We installed the system at the Duck Island facility for testing and a company, in addition to PSE&G, is interested in licensing the pyrometer," said George who's been working with Dr. Zwillenberg. Con Edison, the New York utility, also is interested in the system.

At the demonstration, George and his coworkers explained how the system works. George said, "Basically, all bodies (including the human body) emit light which varies in wavelength and intensity. Both wavelength and intensity are temperature dependent. Using the radiation laws, you can determine the temperature of a body by measuring the amount of light emitted in two close wavelengths. A two-

color system helps reduce some errors which are normally encountered in a one-color system.

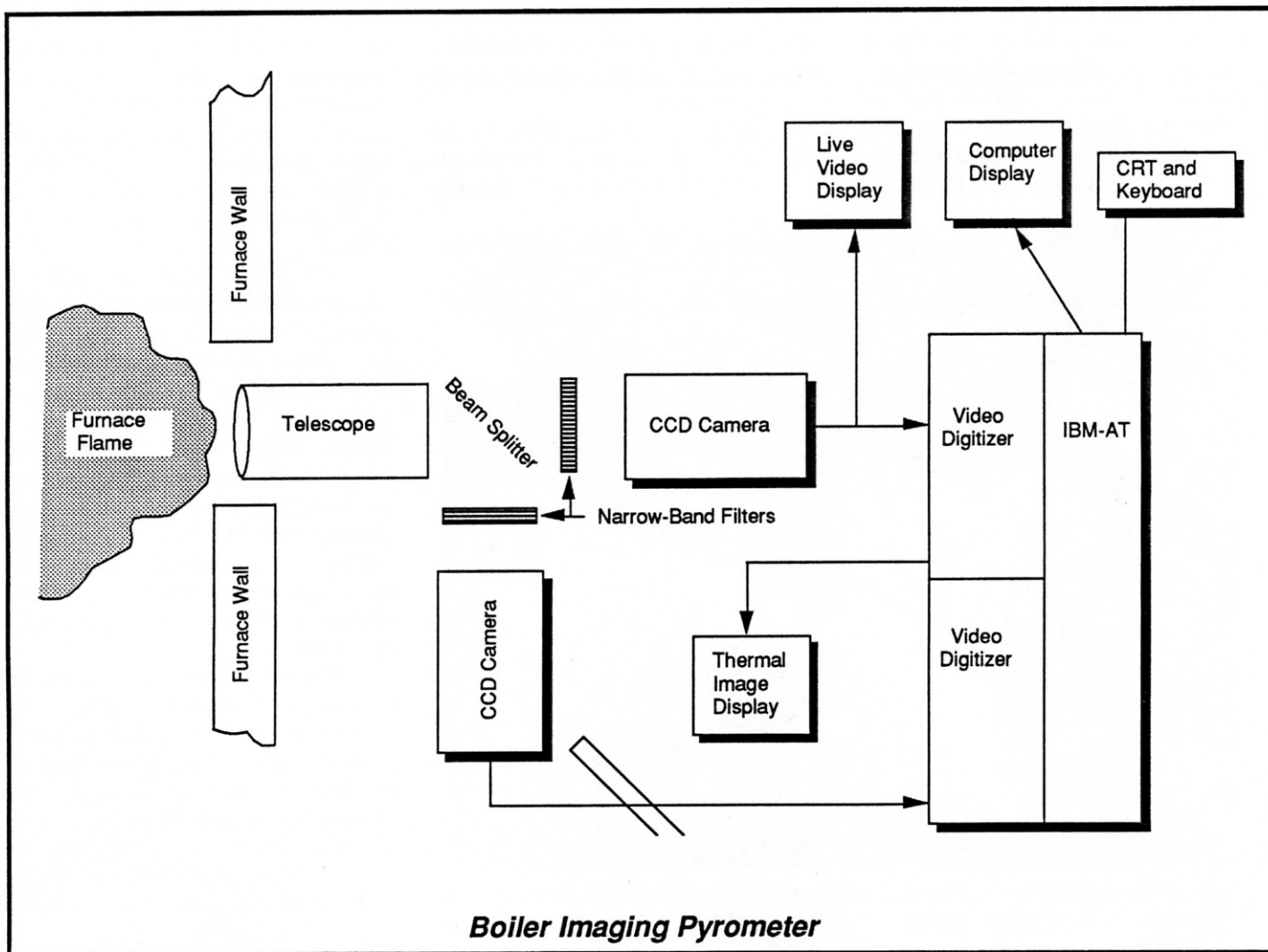
"In the PSE&G system we developed, the periscope views the furnace flames through a 90° field of view. The light is separated by the beam splitter and passes through two spectral filters. The light is then converted to an electrical signal by two CCD cameras. This means each camera contains the same spatial image but their intensity varies because each image is from two different wavelengths."

George explained, "The computer receives the resulting signals and processes the raw data to obtain the ratio of the intensity of any point in the optical image at the two selected optical wavelengths. Each image is composed of approximately 250,000 picture elements. The ratio is then compared to the ratio of the intensity of blackbodies at the same wavelengths to

determine the temperature of the burner flame. The processed image is then converted to eight bands of colors and displayed on a color monitor as a thermal image where each color represents approximately a 200° F change."

He continued, "A new thermal image is then processed and displayed every ten seconds. The images can be recorded on a videotape and selectively recorded on the computer's hard disk. More quantitative results can be obtained by freezing an image of interest and temperature, then plotting the rows and columns of interest."

George and Greg are obviously happy with their new creation. "We spent many months devising the pyrometer," said George. "We're pleased with our accomplishment and look forward to PSE&G's test results so we can refine the system. It signals another step toward energy saving for the future."



## JT-60 Progress

The world's largest tokamak, the JT-60 in Japan, has successfully completed its first phase of operations and was recently shut down for extensive upgrading. Values of the plasma density-confinement time-temperature product ( $n\tau T$ ) of  $1.3 \times 10^{14} \text{ cm}^{-3} \text{ sec keV}$  were obtained using pellet injection — about double the value obtained in gas-fueled discharges. Experiments on lower hybrid current drive were also carried out using a newly-developed multi-

junction type launcher. A current drive efficiency of  $3 \times 10^{19} \text{ m}^{-2} \text{ A/W}$  was attained, an efficiency which approaches that required for ITER-class machines.

The upgraded machine, called JT-60U, is expected to begin operations about a year from now. It will be capable of 6 MA of plasma current in noncircular divertor deuterium plasmas and will be equipped with 40 MW of neutral beams, 8 MW of ICRF and 15 MW of lower hybrid power.

We congratulate our Japanese colleagues on their many successes in fusion. For further information contact Dr. Akira Oikawa, Japan Atomic Energy Research Institute, Tokai, Naka Ibaraki 319-11, Japan.

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## For Don Harnsberger, It's Up, Up & Away!

by Phyllis Rieger

As PPPL mechanical engineer Don Harnsberger tells the tale, "It all started at Oshkosh '85, . . ."

That's when he flew to Oshkosh, Wisconsin, for the annual exhibition of the Experimental Aircraft Association, a nationwide organization of 120,000 people interested in aviation. "Since I learned to fly in 1944, I've always loved flying," said Don who explained his father was an enthusiastic flier.

"For the exhibition about 15,000 aircraft fly in and it's airplane heaven," he said. The heavenly design he liked was the Aero Mirage TC-2, a futuristic looking plane with a very slim profile and light weight (750 lbs empty, 1200 lbs gross), based on the use of Kevlar and fiberglass "skins" bonded with vinylester resins. It has an advertised performance of 200 mph with a 100 horsepower Continental power plant.

Don thought about it for two months and decided, why not? Yes, he'd build his own plane. He traveled at year's end to Gainesville, Florida, to pick up the "kit," which only included the fuselage shell and main spar installation. "Very little else was available," explained Don. "Mirage management assured us the other skins and hardware kits would be following soon."

Don continued, "We brought the fuselage and a few miscellaneous parts to Princeton in a U-Haul trailer, built a heated enclosure in half of the garage, and started to work." The "we" includes Don's son, Bob, now 17, who started helping his dad when he was 14.

### Ingenuity+

Don labored throughout 1986, completing the main fuselage assembly and the landing gears. By mid-1987 though, it dawned on him that the "kit supply train" had stopped running. He was now on his own. Creativity and ingenuity mixed with hard work helped him to devise the other parts he needed. Following occasional consultation with PPPL tech shop personnel who also lent him moral support, he completed fuel tank and control bracket fabrication, hydraulic system components, engine mounting adapters, exhaust pipes, etc.

He persevered and finally by August, 1989, had the plane completed. Lee Benson's (a former PPPL employee) race car trailer provided the means of transport

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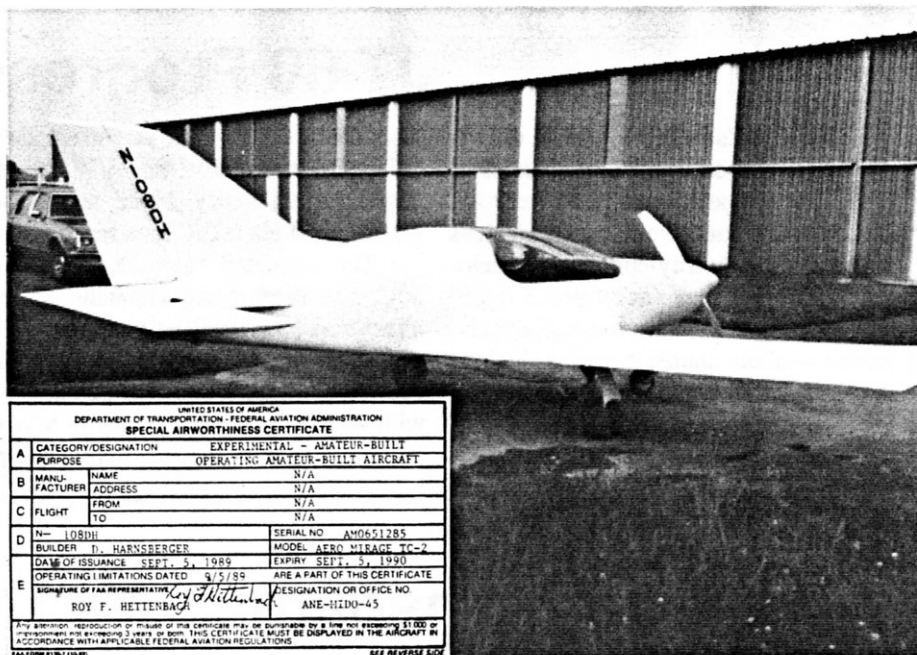
*The Aero Mirage TC-2, built by Don Harnsberger.*

to Princeton Airport where the wings were reinstalled and the control and final wiring connections made in preparation for "taxi-testing." During the taxi tests the speed was gradually built up to 70 mph to "feel out" the plane's stability and lift-off capabilities, leading up to the issuing on September 5th of the "Special Airworthiness Certificate," a piece of paper as valuable as gold for someone like Don. "It means the Federal Aviation Administration (FAA) inspector has ascertained my plane is ok to fly for 40 hours until the next and final inspection," said Don. "I can't have a passenger until that final step," he explained. "And a flight is restricted to a 25-mile radius from 'home port.'" He also has a special construction log book, required by the FAA, which documents all the work he did.

### "... Like a Dream"

He made his first flight on September 7th and some ten hours of flight time had been logged through mid-October. Don reports, "It handles like a dream with good stability and quick maneuvering capabilities."

Once he has his final certificate, he already has three special trips planned. The first to the Experimental Aircraft Association meeting in Florida, scheduled for



**For Don Harnsberger, building his own plane meant one of his dreams became a reality. The "Special Airworthiness Certificate" (Inset) is as valuable as gold.**

spring, 1990; the second to visit friends in Houston, and the third to the Association's Annual Exhibition in Oshkosh in August.

"I have to get the plane's performance all mapped out," said Don. "It holds 25 gallons of fuel, about four hours of flying time at 175 mph. That's good gas mileage."

## TRANSITIONS

The HOTLINE offers congratulations to the following employees:

### Births

**Karen Tuttle-Frank**, Computer Division, and her husband, Alan, whose daughter, Emily Katherine, was born January 25.

### Retirements

**Harry Anderson** retired after 17 years of service. Harry was a Radio-Frequency Technician in Technical Operations.

**Henry Bornkamp** retired after 12 years of service. Henry was Manager of Subcontracts in the Procurement Division.

**Uffe Christensen** retired after 33 years of service. Uffe was a Principle Engineer in the Engineering Analysis Division.

**James Clark** retired after 7 years of service. Jim was Deputy Director for Administration Operations.

**Hsi Feng** retired after 13 years of service. Hsi was an Engineer in Technical Operations.

**Samuel Goldfarb** retired after 14 years of service. Sam was a Senior Engineer in Technical Operations.

**Joseph Kittel** retired after 29 years of service. Joseph was a Technical Associate in the TFTR Neutral Beams Branch.

**Gioetta Kuo-Petravic** retired after 13 years of service. Gioetta was a Project Engineer in the TFTR Diagnostics Application Section.

**Francis Lawn** retired after 10 years of service. Frank was an Electrical Engineer in Technical Operations.

According to Don, "More people are building planes than you think. It's not that unusual." That's news to those of us not airplane aficionados. For Don, building his own plane has meant he's one of the lucky ones who's seen one of his dreams become a reality.

**John Lowrance** retired after 23 years of service. John was an Engineer in Technical Operations.

**Paul McCann** retired after 30 years of service. Paul was a Technical Associate in Technical Operations.

**Arthur Miller** retired after 22 years of service. Arthur was a Technical Associate in the Theoretical Division.

**Melvin Shampianier** retired after 11 years of service. Melvin was a Buyer in the Procurement Division.

**Muriel Strohl** retired after 20 years of service. Muriel was an Administrative Assistant in Technical Operations.

**Conrad Stout** retired after 15 years of service. Connie was Head of the Plant Maintenance and Engineering Division.



# Safety Training

***The Safety Office has scheduled the following safety training course for February:***

<u>Course</u>	<u>Date/Time/Location</u>
<b>CPR TRAINING</b>	<b>28 Feb, 12:30 - 4:30 p.m. LOB Commons</b>
The Center for Emergency Medical Training will conduct this class in the life saving technique of Cardiopulmonary Resuscitation. Recertification is required every year.	

***Employees must obtain permission from their immediate supervisor to attend these classes. Supervisors should call Sue Hill at ext. 2528 to enroll their employees.***

## DOE Sponsors 'Earth Day' Poster Contest

***The U.S. Department of Energy (DOE) is sponsoring a poster contest for elementary-school-aged children as part of the twentieth anniversary celebration of Earth Day. Earth Day recognizes the "necessity for conservation of natural resources of the world." Many millions of Americans take part in celebrations and peaceful demonstrations on this day.***



***The theme of the posters is "How I would use science to improve the quality of life." Winning entries will be displayed in the Department's Earth Day Exhibit at DOE Headquarters in Washington, D.C.***



***All young children of PPPL employees are encouraged to participate. Entries should be sent to Information Services, Room B378, by Thursday, March 15. The name, age, and grade of the artist, as well as the name of the parent and his/her Laboratory telephone extension should be printed clearly on the back of the poster. Posters will be forwarded to the DOE for judging. Participants will be informed if their posters are selected for display.***

Editor: Carol Phillips

Photography: John Peoples

Dietmar Krause

Layout: Terry Birch

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Our best story ideas for HOTLINE come from you. So if you have an idea for an article, call Carol Phillips at ext. 2754.

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