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# HISTORY OF THE DEVELOPMENT OF US PATENT 8,391,552

***Method of Particle Trajectory Recognition in Particle Flows of High Particle Concentrations using a Candidate Trajectory Tree Process with Variable Search Areas***

**Inventor: Franklin D. Shaffer**

**DOE Patent Attorneys: James B. Potts, Mark P. Dvorscak and John T. Lucas**

**This report describes the huge investment in funds (millions of US taxpayer dollars), the huge investment in engineering time (more than 20 years of engineering time), and one of the largest labs in the USDOE with access to nuclear weapons technologies that went into the development of the technology that would become US Patent 8,391,552 in 2013.**

**Development of the technology that would become 8,391,552 began in the late 1980's in the Particle Flow Analysis Laboratory at the US Department of Energy's Pittsburgh Energy Technology Center. The Particle Flow Analysis Lab was the largest laboratory at the USDOE Pittsburgh Energy Technology Center (and likely the largest lab in the world for the study of multiphase flows). It was in the "High Bay" of Building 84, the Analytical Chemistry Building. It was in operation from 1988 through 2009.**

**Wind tunnel of the Particle Flow Research Laboratory, in operation from 1988 through 2007**

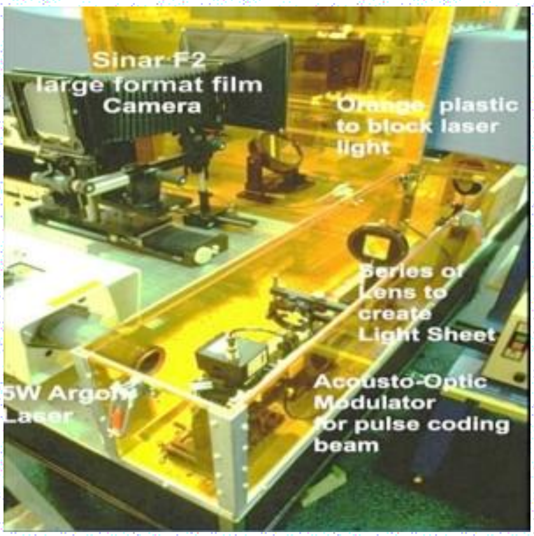
**Particle Tracking Velocimetry (PTV) requires particles to be exposed (illuminated) many times along their trajectories as they pass through the view of a camera. In the late 1980's, pulsed illumination sources with (1) repetition rates high enough, (2) pulse energies high enough to expose the silver halide film of high-speed cameras of that time with scattered light from**

**small (<100 μm)refractive or reflective particles, and (3) pulse durations short enough (<100 μsec) to freeze the motion of said particles had not yet been developed.**

**At that time, to produce high-resolution velocity maps of particle flow fields, the only option was to use two high-powered pulsed lasers, e.g., Q-switched Rudy or Nd:Yag lasers, to double expose a large-format silver halide film plate. The name for that technology was coined by Ronald Adrian and Thermo Systems Inc (TSI) as *"Particle Image Velocimetry (PIV)."***

**If the Stokes number of the particles is <<1, the velocity of the seed particles is the same as the velocity of the gas or fluid flow. In this case, the velocity of the gas or fluid flow is measured by the velocity of the seed particles.**

**The photo below on the left shows my large format Sinar F2 camera on the viewing port of the wind tunnel in my Particle Flow Analysis Laboratory. The photo on the right shows the large format film plates for the Sinar F2. We used both 4" x 5" and 8" x 10" film plates. We had our own dark room to develop the large format film.**




**Sinar F2 large format film camera on the viewing port of the wind tunnel in the Particle Flow Analysis Lab.**

**The 4" x 5" and 8" x 10" large format film screens of the Sinar F2**

**One of the first high-speed cameras that we used for PTV was the Kodak Spin Physics SP2000. To my knowledge, the SP2000 was the first high-speed film camera to have a digital photo-electric image sensor. The data from the photo-electric image sensor was recorded on magnetic film. To my knowledge, the SP2000 was also the first high-speed camera with rudimentary digital motion analysis tools. This enabled PTV, albeit in a very laborious manner. The resolution of the SP2000's image sensor was 192 x 240 pixels (picture elements). In 1988, the DOE Pittsburgh Energy Technology Center purchased a Kodak Spin Physic SP2000 high speed camera for $250,000 ($700,000 in 2023 dollars).**

**The Kodak SP2000 had a washing machine sized console. In total, the Kodak SP2000 Motion Analysis System weighed 300 lbs. The magnetic film cassette**

of the SP2000 had to be mailed to Kodak for processing. The turnaround time was one month.

The SP2000's 20"x20"x40"console.

SP2000 Motion Analysis System

Magnetic film cassette

**For our first work to develop PTV, we used Xenon strobe lights and acousto-optically modulated (AOM) Argon lasers.**

To the right is a screen shot of our first attempt at digital PTV in 1988 with the SP2000. It is the first digital PTV I'm aware of. The screen shows the multiple-exposure of droplets along their trajectories near the film-droplet interface of a J22 fuel spray nozzle. The frame rate was 2000 per second. The pulsed illumination source was an acousto-optically modulated Argon laser. The pulse rate was 300 kHz with one microsecond pulse durations.


Photo of the Kodak SP2000 screen showing PTV of droplets near the film-droplet interface of a J22 fuel nozzle.

### *Nomenclature of what would become US Patent 8,391,552*

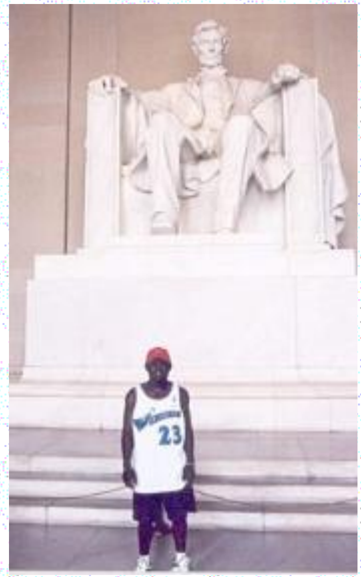
In the late 1980's, the name "Particle Tracking Velocimetry" had not yet been coined. In 1988, this engineer and a PhD Nuclear Engineer, Dr. Everett Ramer, used the name *"Pulsed Laser Velocimetry (PLV)"* in our paper at the American Institute of Aeronautics and Astronautics (AIAA) First National Fluid Dynamics Conference: *Development of Pulsed Laser Velocimetry Systems with Photo-Electric Image Sensors*

In 1992, we used the name *"Multiple Pulse Particle Image Velocimetry (MMPIV)"* in our paper *Automated Analysis of Multiple Pulse Particle Image Velocimetry Data* in the Journal of Applied Optics, Vol. 31, Issue 6.

### *My Abraham Lincoln Atomic Vapor Laser for PTV*

**In 1988 I was able to procure a copper-vapor laser as a pulsed-illumination source. Our copper-vapor laser was built the engineers who built them for the DOE Los Alamos National Laboratory (LANL). Copper-vapor lasers are also known as "Atomic Vapor Lasers" because they are used to "pump" dye lasers in the Atomic Vapor Isotope Separation (AVLIS) process to enrich uranium to weapons grade plutonium. To the knowledge of this author, this was the first AVL from Los Alamos used strictly for civilian applications, namely, Particle Tracking Velocimetry (PTV) and flow visualization.**

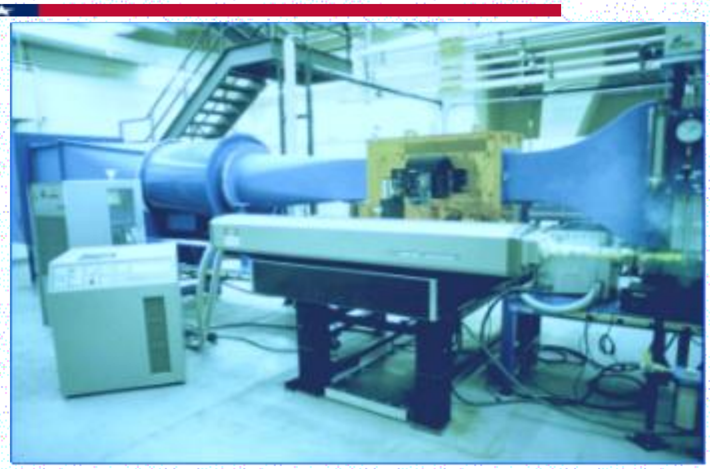
**I called it "my Abraham Lincoln Laser" because in the late 1980's it was easy to find Lincoln pennies were nearly pure copper (pre-1983). I'd drop a Lincoln penny in my AVL, and out would come the power to protect our country with nuclear weapons.**



Abednego Soita, now an Electrical Engineer with JGL, building advanced vehicles for the US military.

**When my family "adopted" a 16-year-old kid from Kenya, the first place my brother took him to was the Lincoln Monument. Or father, Reverend Dr. Dallas B. Shaffer, was a Civil War historian. His PhD dissertation was on Lincoln wielding the sword of the Union Army to slice Virginia in half, to make a more perfect union, the United States of America. Click here for my father's publications, including *"Lincoln and the Vast Question of West Virginia"***

The green (511 nm) and yellow (578 nm) beams of my Atomic Vapor Laser.



Atomic vapor laser and wind-tunnel of the Particle Flow Research Laboratory.

Sec. of Energy Herrington, Asst. Sec of the Navy

**Because Atomic Vapor Lasers are a technology used to develop nuclear weapons, my procurement and use of an AVL had to be approved by the Fifth Secretary of Energy John S. Herrington, a former Assistant Secretary of the Navy. In 1992, the Sixth Secretary of Energy, Four Star Admiral James D. Watkins, former Chief of Naval Operations and Commander of the Pacific Fleet, visited my lab to see my work with the AVL.**

Sec. of Energy Watkins, Chief of Naval Operations

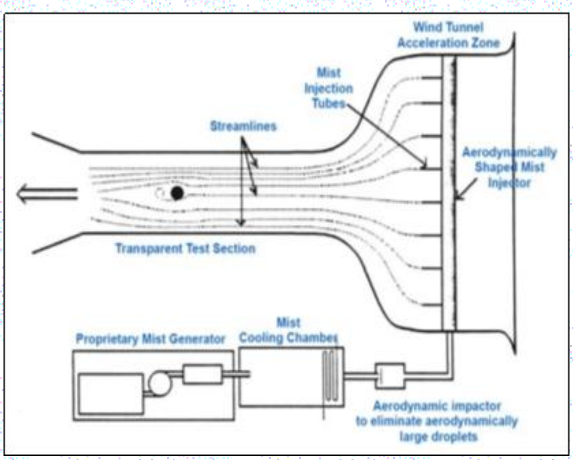
**The photo to the right is of Distinguished Professor Dr. Harvey S. Borovetz explaining to Admiral Watkins how the bovine tri-leaflet valve of the Novacor Left Ventricular Assist Device works.**

***FUN FACT*: The first chemical laser (Light Amplified by Stimulated Emission of Radiation) was developed in 1965 by Jerome V. V. Kasper and George C. Pimentel at the University of California, Berkeley. It was a hydrogen chloride laser emitting at a wavelength of at 3.7 micrometers. I visited his lab when I was working at UC Berkeley with Professor Ömer Savaş.**

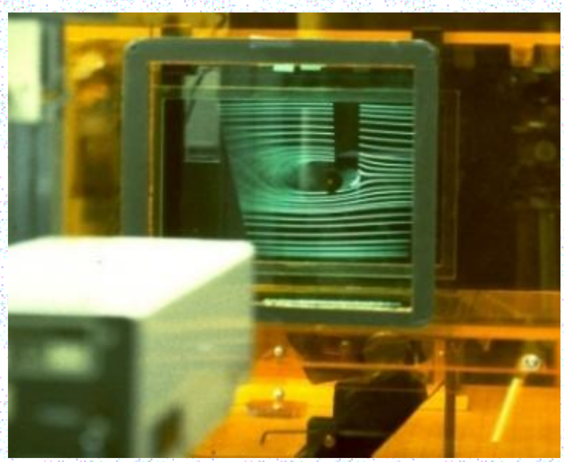
Admiral Watkins visiting my lab

### *Streakline Visualization System with an Atomic Vapor Laser*

**The streakline flow visualization system for the wind tunnel is shown below on the left. Streaklines over a circular cylinder illuminated by the Atomic Vapor Laser are shown on the right. A Dage MTI 81 camera was used. It had a phosphorus cathode image sensor with 2000 analog scan lines. The analog signal was digitized at a resolution of 2000 x 2000 pixels with an Androx Analog-to-Digital Convertor in a Sun 670 workstation. It was custom built by engineers at the CMU Robotics Institute.**



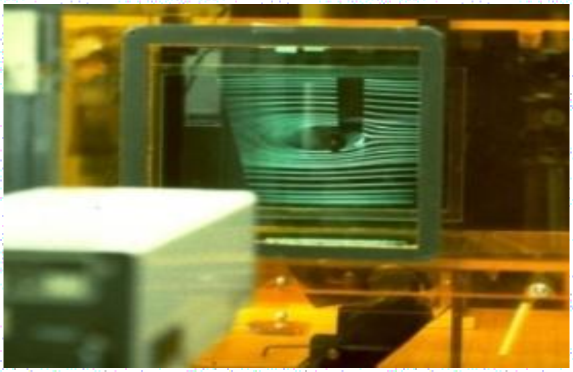

Custom streakline visualization system for the wind tunnel of the Particle Flow Analysis Lab.



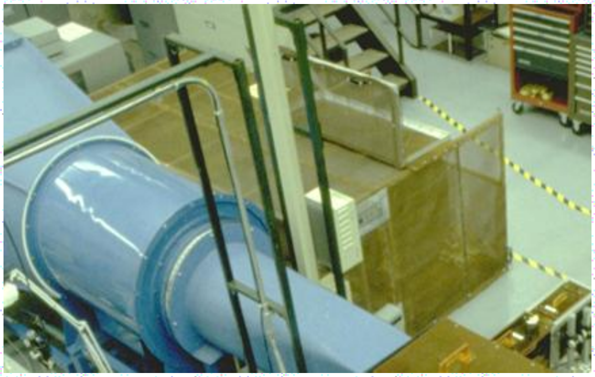
Streaklines illuminated with our Atomic Vapor Laser. A Dage MTI-81 camera is shown.

The large capacitors of the AVL had to charge and discharge 10,000 times per second. The capacitors were discharged in less than 50 nanoseconds. This generated very high levels of Electromagnetic Radio Frequency (EMI/RFI) noise. The EMI/RFI noise showed up on the photo-electric image sensors of cameras as horizontal lines and dots, as shown below. The photo below on the left shows the trajectories of three particles recorded on a Dage MTI-81 camera, one colliding with a cylinder. The camera frame is overlain with the EMI/RFI noise pulses from the Atomic Vapor Laser.

The EMI/RFI noise also showed up on every spectrometer in the Analytical Chemistry Building. In an effort to try to shield and ground the EMI/RFI noise, Dr. Richard Sprecher, a PhD Chemist from CMU, and an inventor of Nuclear Magnetic Resonance Imaging (NMRI) technologies, helped me design a Faraday cage to enclose the AVL (shown below on the right). It was made of a ½" thick copper screen (a double layer of ¼" thick copper screen). It was able to shield the EMI/RFI enough for spectrometers to wsork, but the EMI/RFI noise still showed up on the image sensors of the photoelectric cameras used in the Particle Flow Analysis Laboratory.



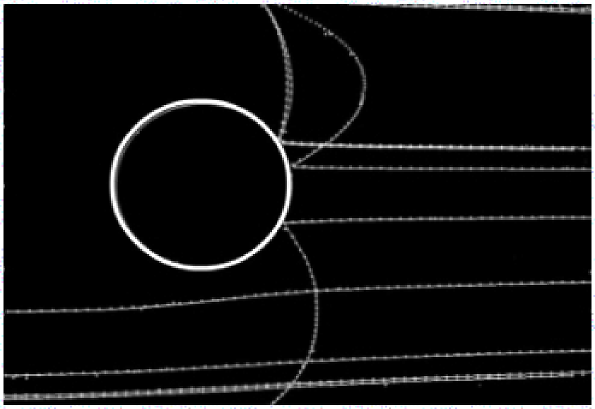
A camera frame showing the trajectories of three particles overlain with EMI/RFI noise from the Atomic Vapor Laser.



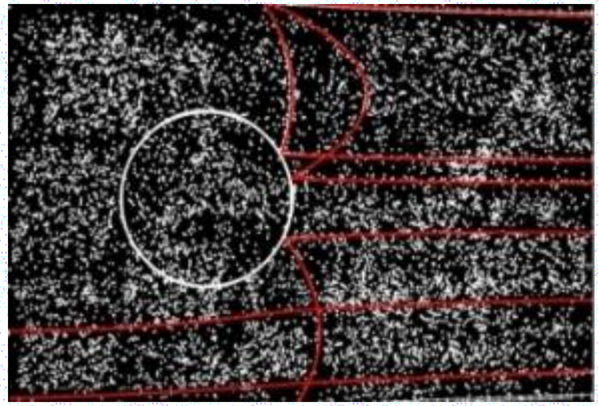
Faraday cage enclosing the Atomic Vapor Laser, designed by Dr. Richard Sprecher.

Although the particle flows being studied at that time were at low particle concentrations, the EMI/RFI noise from the Atomic Vapor Laser produced artificial "particle" images. This made the flow field appear as a particle flow with very high particle concentrations. *This was the reason driving the initial development of algorithms for high concentration PTV (hcPTV).*

To develop particle tracking algorithms that could discern between real particle images and the artificial EMI/RFI noise "particles," Computational Fluid Dynamics (CFD) simulations of particle flows at low particle concentrations were created, then artificial noise particles were added at increasing concentrations. We gradually increased the concentration of noise particles until the image was filled with them.



CFD simulation of particle trajectories past a circular cylinder.



Trajectories identified in a CFD simulation with very high concentrations of added noise particles.

**The code that implemented the particle tracking algorithms that I developed with Dr. Ramer was written by Ramakrishna Srinivan and Ramanand Singh. Both have Master of Sciences Degrees in Computer Engineering. Here's a link to their original code in C language, called *"Trajectory Formation."* It is ~1500 lines of C+ code.**

**We tested many types of pulse coding schemes for hcPTV. We describe and evaluation of them in our papers *Analysis of Pulse-Coded Particle Tracking Velocimetry Data* , by Ramakrishna Srinivasan, Ramanand Singh Science Applications International Corporation (SAIC), and Franklin Shaffer, USDOE Pittsburgh Energy Technology Center, IEEE International Conference on Pattern Recognition, Copenhagen, Denmark, September 1991, and *"Fluorescent Image Tracking Velocimetry algorithms for quantitative flow analysis in artificial organ devices,"* by Ramanand Singh, Franklin Shaffer, and Harvey Borovetz, University of Pittsburgh Medical Center Artificial Heart Program, in the peer-reviewed Journal of the International Society for Optics and Photonics, SPIE, Volume 1905, pages 281-292, 1993**

**PTV algorithms were developed and tested for three pulse-coding schemes — a single-pulse code, a dash-dot pulse code, and a constant-frequency pulse code. The algorithms were tested on flow fields in three types of artificial cardiac organs: the Baxter Healthcare Novacor Left Ventricular Assist System, the Nimbus AxiPump, and the Hattler Intravenous Membrane Oxygenator. A constant-frequency pulse coding scheme was found to provide superior results for these applications, despite the drawback of time-direction ambiguity.**

**In 1994, I planned to make the PTV system commercially available. It would use an Atomic Vapor Laser and software for PTV using the algorithms I developed with Dr. Ramer. SAIC agreed to fund the commercialization. Here's a link to the proposal I wrote for SAIC. Unfortunately I had to abandon the commercialization effort because it would require that I travel throughout the US and Europe.**

**On September 8, 1994, Flight 427 went down on its approach to Pittsburgh International Airport. Five engineers from the Pittsburgh Energy Technology Center went down with 427.**

**On September 8, 1994, I was visiting friends near Monaca, PA. Suddenly the entire region was suddenly filled with the sound of sirens and lights from first responders. I thought there'd been an accident at the nearby Shippingport Atomic Power Station. It was the crash of Flight 427.**

**I knew all five engineers who went down on 427. Dr. Bill Peters funded my research on high-concentration particle flows. I played tennis with Tom Arrigoni. Tim McIlvried, a fuel scientist from Penn State, was in the office beside mine in Building 84. He was my age, 32. I went to five funerals in a week. I've had trouble flying since then. I simply could not do the travel required to market the PTV system.**

# Loss is personal, professional at energy office

By Don Hopey
Post-Gazette Staff Writer

There seemed to be a hole deeper and darker than a coal pit at the Department of Energy office in South Park yesterday, where stunned, numb workers mourned the deaths of five of their best and brightest aboard Flight 427.

William C. Peters, Robert J. Evans, Steven J. Heintz, Thomas W. Arrigoni and Timothy S. McIlvried worked on the DOE's $7 billion program for developing ways of burning coal with as little air pollution as possible. They were returning from the third annual Clean Coal Technology Conference in Chicago.

"This is a big loss for their families and a big loss for the government's clean coal program. We here are all very, very sad," said Joseph P. Strakey, associate director for clean coal technology at the Pittsburgh Energy Technology Center.

"We all work together on clean coal project teams, that's why this loss is so personal," he said as other employees moved quietly through the halls, or gathered in small knots to talk in hushed tones.

The South Park center manages 28 of the DOE's 45 clean coal demonstration projects. The remainder are administered out of the department's Morgantown Energy Technology Center, which lost four employees in the crash.

Those employees have been identified as William Langan, director of the Power Systems Technology Division, and project managers Holmes Webb, Manville Mayfield and Randall Dellefield. Langan's wife, Shirley Langan, also died in the crash.

Also killed while returning from the conference was Edwin Wiles, an Upper St. Clair resident who was former president of the West Virginia Coal Association.

A total of 17 employees from the DOE's Pittsburgh office attended the Chicago conference. After hearing about the crash, some changed plans and began driving back to Pittsburgh yesterday.

"We're just all numb right now," said Patrice Leister, spokeswoman for the center and Strakey's wife. Both were on a USAir flight that left Chicago about an hour after Flight 427.

"We were going crazy after we got back in and found out what happened," Leister said, "calling people from the airport, trying to find out who was on the flight."

Peters, 54, of McMurray, Washington County, had worked at the DOE's office in South Park since 1969, and headed a very successful cooperative project in India.

Evans, 52, of Venetia, had 30 years experience at DOE, and managed four clean coal projects with a total investment cost of $150 million.

Arrigoni, 49, of McMurray, had worked at the DOE for 16 years, was one of the four original members of the Pittsburgh Clean Coal Management staff and managed three projects.

Heintz, 41, a Mars resident, had worked for the government for 15 years, and managed three projects, including one in Alaska near Denali National Park. He was to be profiled in next month's DOE magazine.

McIlvried, 32, who lived in Bethel Park, began working at the DOE in 1987, shortly after graduating with a masters degree in fuel science from Penn State University. He did technical analysis and engineering support on a number of projects.

Sun W. Chun, director of the Pittsburgh Energy Technology Center, said that if he hadn't left the Chicago conference early for a meeting in Washington, D.C., he probably would have been on USAir Flight 427.

Chun could only shake his head at the luck, good and bad. "This is a small, tight-knit organization. Those men were like my brothers. I have traveled to Montana, to India — all over — with those men. I don't know how to express my sorrow in this regard."

Chun said the men who died were important participants in developing clean coal technology. "I don't know how to replace their management and technical training," he said. "We lost such a valuable asset for our organization and for our country."

**Below is a list of my publications on the development and application of high concentration Particle Tracking Velocimetry (hcPTV):**

1. ***On the Essential Role of Nuclear Weapons Technologies in the Development of US Patent 8,391,552. A presentation in honor of Congressman Harley O. Staggers Sr and Attorney Congressman Harley O. Staggers Jr*, original version, Multiphase Flow Event, Morgantown, WV, August 14, 2024**
2. ***On the Essential Role of Nuclear Weapons Technologies in the Development of US Patent 8,391,552. A presentation in honor of Congressman Harley O. Staggers Sr and Attorney Congressman Harley O. Staggers Jr*, version censored by the NETL, Multiphase Flow Event, Morgantown, WV, August 14, 2024**
3. ***Visualization of submerged turbulent jets using particle tracking velocimetry*, Franklin Shaffer, Eric Ibarra and Ömer Savaş, UC Berkeley Department of Mechanical Engineering, Journal of Visualization, Feb 15, 2021**
4. ***On the near field interfaces of homogeneous and immiscible round turbulent jets*, Eric Ibarra, Franklin Shaffer, and Ömer Savaş, UC Berkeley Dept of Mech Engr, Journal of Fluid Mechanics, Volume 889, February, 2020**

5. *Investigation of rope formation in gas–solid flows through a 90° pipe bend using high-speed video and CFD simulations*, Sai S Guda, Steven L Rowan, Tao Yang, Franklin Shaffer, Ismail B Celik, The Journal of Computational Multiphase Flows, April 2018
6. *Analysis of a Vortexing CFB for Process Intensification via High-G Flows*, Michael Bobek, Steven L Rowan, Jingsi Yang, Justin Weber, Franklin Shaffer, Ronald Breault, Journal of Energy Resources Technology, Volume 40, Issue 6
7. *Statistics of velocity fluctuations of Geldart A particles in a circulating fluidized bed riser*, Vaidheeswaran, Avinash, Shaffer, Franklin D., Gopalan, Balaji, Physical Review Fluids, Nov 21 2017, 10.1103/PhysRevFluids.2.112301
8. *Underwater oil jet: Hydrodynamics and droplet size distribution*, Lin Zhao, Franklin Shaffer, Brian Robinson, Thomas King, Christopher Ambrosea, Zhong Pana Feng, Gao Richard S. Miller, Robyn N.Conmye, Michel C.Boufadel, Chemical Engineering Journal, Vol 299, Pages 292-303, 1 Sep 2016
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13. *A Pitot tube system for obtaining water velocity profiles with millimeter resolution in devices with limited optical access*, Ronald J.Lynn, Igor V.Haljasma, Frank Shaffer, Robert P.Warzinski, Jonathan S.Levine, Journal of Flow Measurement and Instrumentation, Vol 40, Pages 50-57, Dec 2014
14. *High speed imaging of particle flow fields in CFB risers,* F. Shaffer, Goplan, B., Breault R.W., Cocco, R., Karri, S.B.R., Hays, R., Knowlton, T., Journal of Powder Technology, vol 75, pp. 1-14, 2013. Full paper
15. *Particle cluster dynamics during fluidization,* Jennifer McMillan, Frank Shaffer, Balaji Gopalan, Jia Wei Chew, Christine Hrenya, Roy Hays, S.B. Reddy Karri, Ray Cocco,, Chemical Engineering Science, 2013, vol. 100, pp. r 39-52.
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17. *Hydrates in the Ocean beneath, around, and above Production Equipment*, Karl Anderson, Gaurav Bhatnagar, Daniel Crosby, Greg Hatton, Philip Manfield, Adam Kuzmicki, Nevil Fenwick, Juan Pontaza, Moye Wicks, Scott Socolofsky, Cole Brady, Steve Svedeman, Amadeu K. Sum, Carolyn Koh, Jonathan Levine, Robert P. Warzinski, and Franklin Shaffer, Energy & Fuels, 26, 7, pages 4167-4176, June 19, 2012
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Savas, and Frank Shaffer, Proceedings of the National Academies of Science, Special Feature Perspective, 109 (50) 20260-20267, December 11, 2012

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24. *CFD Analysis of a Respiratory Assist Catheter,* G. Burgreen, N. Moore, B. Frankowski, F. Shaffer, B.Gopalan, W. Federspiel, Journal American Society Artificial Internal Organs, May 2010.
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27. *A Hot Gas Cleanup Filter Design Methodology*, J.G. VanOsdol, R.A. Dennis and F.D. Shaffer, Advanced Coal-Fired Power Systems, 1996
28. *Long Time-Averaged Solutions of Turbulent Flow Past a Circular Cylinder* , Celik, I. and Shaffer, F., Journal of Wind Engineering and Industrial. Aerodynamics, 56, 185-212, 1995
29. *The Aerodynamic Behavior of Charged Particles in an Electrostatic Separation Process*, Doney, J., Sinclair, J., Finseth, D., and Shaffer, F., ASME Fluids Engineering Division Meeting, Symp. on Gas-Solid Flows, Hilton Head, NC, August 1995
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32. *Measurement of Diffuse Particle-Wall Collision Properties* , Massah, H., Shaffer, F., Sinclair, J., and Shahnam, M., Fluidization VIII, Compiegne, France, May 1995
33. *Non-Intrusive Measurement of Particle-Wall Collision Properties*, Massah, H., Shaffer, F., Sinclair, J., and Shahnam, M., AIChE Annual Meeting, San Francisco, CA, November 1994
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35. *Vortex Ring Formation and Mixing in Laminar Air Flows*, Hura, H., Breen, B., Shahnam, M., and Shaffer, F., Soc. of Engr. Sci. Ann. Meeting, College Station, Texas, October 1994
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54. *Overview of Pneumatic Transport Research at the USDOE*, **George Klinzing, Mahendra Mathur, Franklin Shaffer, et al., Pittsburgh Energy Technology Center, Pneumatech 4, Glasgow, Scotland, June 1990**

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64. ***Gas-Solid Flow Metering Method Based On Differential Pressure Measurements,*** **Shaffer, F., and Bajura, R.A., A Proc. of the AIAA/ASME Fourth Fluid Mechanics, Plasma Dynamics and Lasers Conf., Atlanta, GA, May 1986**

65. ***A Differential Pressure Based Gas-Solid Flow Metering Method Applicable to the Intensively Circulating Fluidized Bed System,*** **Shaffer, F., M.S. Thesis, West Virginia University, 1986**

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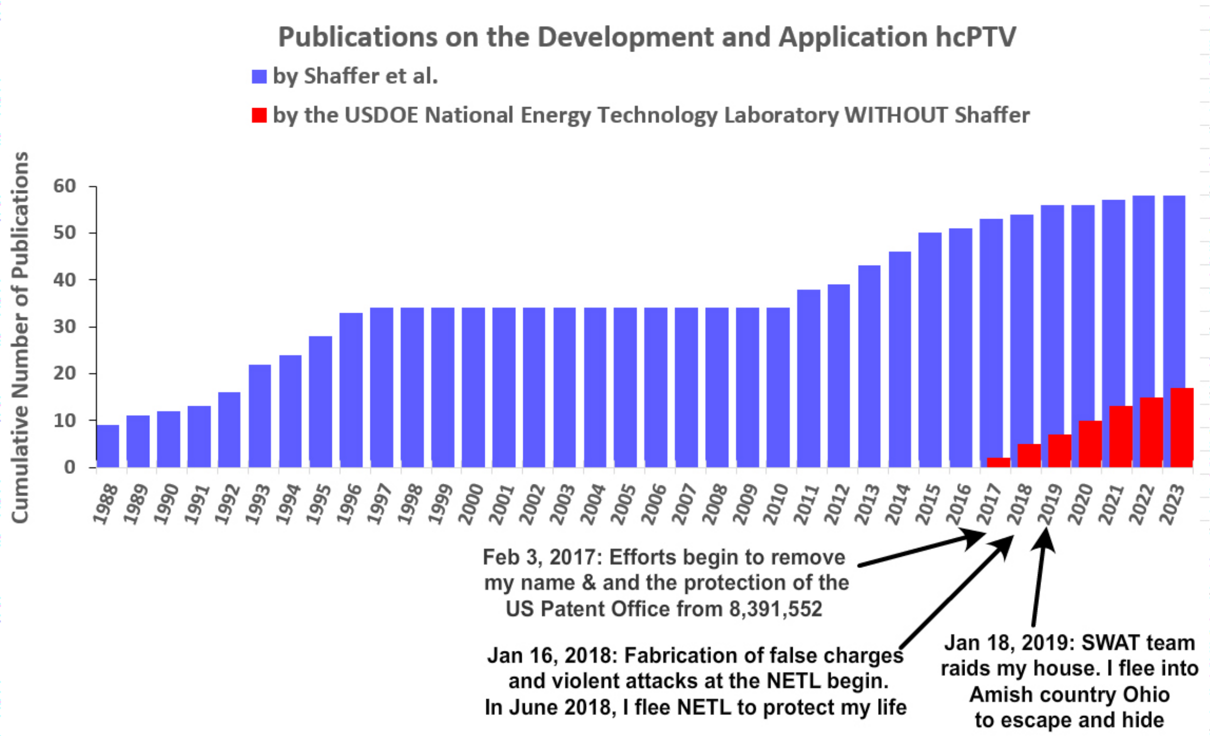
**The chart below shows the chronological cumulative number of my publications on the development and application of hcPTV, and the same for NETL without me (by Breault & Weber). Before Breault attacked me forced to flee the NETL to protect my life so he and Weber could engage in espionage, Breault and Weber had no experience with hcPTV.**




**This is the flowchart for the FORTRAN (Formula Translation) code that implements US Patent 8,391,552. It is more than 6000 lines of FORTRAN code. To read the flowchart, I had a 5' x 4' print made and hung it on the wall of my office.**

**Click here or on the flowchart to download the entire FORTRAN code.**

# Loss is personal, professional at energy office

By Don Hopey
Post-Gazette Staff Writer

There seemed to be a hole deeper and darker than a coal pit at the Department of Energy office in South Park yesterday, where stunned, numb workers mourned the deaths of five of their best and brightest aboard Flight 427.

William C. Peters, Robert J. Evans, Steven J. Heintz, Thomas W. Arrigoni and Timothy S. McIlvried worked on the DOE's $7 billion program for developing ways of burning coal with as little air pollution as possible. They were returning from the third annual Clean Coal Technology Conference in Chicago.

"This is a big loss for their families and a big loss for the government's clean coal program. We here are all very, very sad," said Joseph P. Strakey, associate director for clean coal technology at the Pittsburgh Energy Technology Center.

"We all work together on clean coal project teams, that's why this loss is so personal," he said as other employees moved quietly through the halls, or gathered in small knots to talk in hushed tones.

The South Park center manages 28 of the DOE's 45 clean coal demonstration projects. The remainder are administered out of the department's Morgantown Energy Technology Center, which lost four employees in the crash.

Those employees have been identified as William Langan, director of the Power Systems Technology Division; and project managers Holmes Webb, Manville Mayfield and Randall Dellefield. Langan's wife, Shirley Langan, also died in the crash.

Also killed while returning from the conference was Edwin Wiles, an Upper St. Clair resident who was former president of the West Virginia Coal Association.

A total of 17 employees from the DOE's Pittsburgh office attended the Chicago conference. After hearing about the crash, some changed plans and began driving back to Pittsburgh yesterday.

"We're just all numb right now," said Patrice Leister, spokeswoman for the center and Strakey's wife. Both were on a USAir flight that left Chicago about an hour after Flight 427.

"We were going crazy after we got back in and found out what happened," Leister said, "calling people from the airport, trying to find out who was on the flight."

Peters, 54, of McMurray, Washington County, had worked at the DOE's office in South Park since 1969, and headed a very successful cooperative project in India.

Evans, 52, of Venetia, had 30 years experience at DOE, and managed four clean coal projects with a total investment cost of $150 million.

Arrigoni, 49, of McMurray, had worked at the DOE for 16 years, was one of the four original members of the Pittsburgh Clean Coal Management staff and managed three projects.

Heintz, 41, a Mars resident, had worked for the government for 15 years, and managed three projects, including one in Alaska near Denali National Park. He was to be profiled in next month's DOE magazine.

McIlvried, 32, who lived in Bethel Park, began working at the DOE in 1987, shortly after graduating with a masters degree in fuel science from Penn State University. He did technical analysis and engineering support on a number of projects.

Sun W. Chun, director of the Pittsburgh Energy Technology Center, said that if he hadn't left the Chicago conference early for a meeting in Washington, D.C., he probably would have been on USAir Flight 427.

Chun could only shake his head at the luck, good and bad. "This is a small, tight-knit organization. Those men were like my brothers. I have traveled to Montana, to India — all over — with those men. I don't know how to express my sorrow in this regard."

Chun said the men who died were important participants in developing clean coal technology. "I don't know how to replace their management and technical training," he said. "We lost such a valuable asset for our organization and for our country."

**I named my FORTRAN code "Trajectory_Identification.for" The following went into the development of this flowchart and the Trajectory_Identification code:**

1. **More than twenty years of engineering effort, including years of effort by a PhD Nuclear Engineer.**
2. **Millions of taxpayer dollars.**
3. **The largest, best-staffed, best equipped lab in the world for the study of particle flows**
4. **Behind-the-scenes support from Congressman Harley O. Staggers Sr, Chair of the House Committee on Energy and Commerce.**
5. **Behind-the-scenes support from the Honorable Attorney Congressman Harley O. Staggers Jr, House Judiciary Committee**
6. **Lots of coffee**
7. **Lots of prayer**

**After Breault used fabricated false charges against me and used violence to force me to flee from the NETL to protect my life, he and Weber claimed they created the same technology of 8,391,552 -- in just a few months.**

**I'd given them an executable version of Trajectory_Identification. To use Patent 8,391,552, all they had to do was enter these basic parameters into a file I named "Exogenous_Input_Parameters_for_Trajectory_Identificaion.txt"**

```
25000       ! Number of camera frames to analyze
12500       ! Camera frame rate in frames per second
1000,1000   ! Camera resolution in pixels
0.005       ! Width of camera field-of-view in meters
```

```
0.005       ! Height of field-of-view in meters
10.0        ! Maximum particle velocity in meters/second
```

**Breault and Weber then illegally transferred the technology of 8,391,552 to the following engineers, who then illegally "proliferated" this technology throughout the world:**

| ENGINEER ENGAGING IN THE THEFT OF MY INTELLECTUAL PROPERTY, US PATENT 8,391,552 | COMPANY / COUNTRY PARTICIPATING IN THEFT OF MF INTELLECTUAL PROPERTY BY DISGUISING MY US PATENT 8,391,552 AS A NON-PATENTED "OPEN SOURCE" TECHNOLOGY |
|---|---|
| Tingwen Li | Saudi Aramco / Saudi Arabia |
| John Higham | University of Sheffield, University of Liverpool / United Kingdom |
| Bill Rogers | USDOE NETL / China, Israel, worldwide |
| Balaji Gopalan | Saint Gobian / Worldwide |
| Ronald Breault and Justin Weber | USDOE NETL / Worldwide |
| More coming soon… | |

**ABOUT MY FEDERAL SERVICE FOR MY COUNTRY (Return to Homepage)**