Avoiding Disaster by Organizing Disorder
(Three Mile Island ? Deepwater Horizon ? etc.)

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The origin of great catastrophes could lie within a little-known field of physics. The remedies proposed 25 years ago were well received in France and particularly in the United States when they were deployed in technically hazardous situations. Yet those remedies were conceived without understanding that we were dealing with new concepts in physics. We explore, in various texts quoted further, this shadowy area of science.

1 Introduction

On a seemingly calm, windless day thousands upon thousands of molecules constantly move and collide in the microscopic world without our noticing. We believe we remain untouched. Then the wind picks up. It possesses kinetic energy that we can partially capture in wind mills. Sometimes, violent gusts and furious winds arise, destroying buildings in its path and wreaking havoc on the surroundings.
In these extreme situations, what do we do? Nothing! We take shelter and wait until the tornadoes and whipping winds calm.
This is how nature works, and the storms, floods, earthquakes, and other cataclysms are, for human kind, the worst examples.
A similar phenomenon appears in installations that carry fluids. In certain cases, flows driven by strong motive power excite the structure containing it, weakening and sometimes destroying the structure. Flows must absolutely be subdued.
2 The Principle of Least Action

Rational mechanics promotes the idea that all natural phenomena can be reduced to a law of conservation, which is applicable to momentum, angular momentum, kinetic energy (in the case of elastic collision), and energy (in its mechanical aspect).

The equations describing the behaviors of an electromagnetic field (Maxwell), quantum light (Planck, Einstein), wave mechanics (de Broglie), quantum mechanics, and quantum electrodynamics are all reversible laws in relation to time. They obey the principle of least action.

The principle of least action (Fermat, Maupertuis, Euler, et al) proven by analytical mechanics (Lagrange, Hamilton, Jacobi, et al) is based on the following supposition:

"Nature dislikes exhausting itself."

Among all the possible solutions to go from point A to point B, nature chooses the path that minimizes the magnitude of a value, which we call "action".

Physics in this form, taught widely, does not take into account friction. It neglects disorder and entropy, and is therefore powerless to degrade kinetic energy.

More:  Chapter 2 - The birth of physics: From Aristotle to Newton
        Chapter 4 - The laws of conservation
        Chapter 5 - From the principle of least action to the emergence of friction
3 On the Path of Chaos

3.1 Sudden Enlargement: A Reference

Accounting for Friction in Fluid Mechanics.

The structure of water flowing from a faucet has intrigued scholars for many centuries. We know that Leonardo da Vinci was particularly interested in the topic. Descartes likewise devoted considerable attention to studying the laws of vortices. And Newton himself found it worthy to study several of its properties.

When these flows are channeled downstream in a pipe, it becomes even more difficult to capture the underlying physical nature of the flow. This is the problem of Borda’s sudden enlargement in a confined space.

Borda was the first to recognize in 1766 that in this configuration, Bernoulli’s Theorem, as derived from Newtonian mechanics, must be flawed. He determined the energy dissipation resulting from this configuration. Borda thus clearly demonstrated that these dissipations are related to kinetic energy contained in the fluid.

More:

Chapter 4 - The laws of conservation
Chapter 5 - From the principle of least action to the emergence of friction
Chapter 6 - Borda’s sudden enlargement
3.2 Order and Disorder

A Rubik’s Cube with its faces aligned is characterized as ordered. In this situation, entropy is zero. In principle, it can only become disordered and increase its entropy. Solving Rubik’s Cube mindlessly would require several billion years to restore the puzzle to its initial state.

Boltzmann’s entropy $S$ is a measure of disorder $W$ that reigns in the molecular world.

More: Chapter 11 - The Fractal Geometry of Benoît Mandelbrot
Chapter 12 - Deterministic Chaos
Chapter 13 - Order and Disorder
3.3 Spatiotemporal Chaos in Confined Sudden Enlargement

Examples: Strainers, relief valves, connection pipes

Schlieren visualizations highlight worrisome dissipative structures.

Between figures 3 and 4, flows suddenly re-center. We observe the disrupted flows with sudden pressure variations in the device. This is spatiotemporal chaos. These fluctuating flows are dangerous. If they possess strong motive power, the flows excite structures and can destroy them.

More: Chapter 10 - Jumping the sound barrier
Chapter 15 16 - Thermodynamics domains
Chapter 18 - Chaotic turbulence in fluids
Chapter 19 - The hole: a guided tour

Instabilities visualization: http://www.youtube.com/watch?v=AOFpQMS3uE8
4 Applying the Principle of Worst Action: A Novel Concept

Because we have not destroyed their kinetic energy, jet fluids degrade this energy themselves by forming dissipative structures that perturb the installations.

Is it wise to allow the flows to behave in such an uncontrolled manner, leading to spatiotemporal chaos when we know that the dissipated motive power can reach megawatts?

4.1 The Entropic Vistemboir, Kinetic Energy Degrader

In the cavity, considerable differences in speeds are created between the central supersonic flow and peripheral subsonic flows. This difference in speeds is greater than the average speed of the molecules; the molecules’ movement must be affected.

We force the flow to mix brutally. The exchange of momentum is intense. The flow is subsequently stable with rapid degradation of kinetic energy.

This is an example of bad fluid mechanics, but it will prove highly useful to subdue flows.
4.2 The entropic vistemboir - Application to Control Valves

In thermal power plant regulation systems, the motive power to be degraded in control valves under partial loads can attain a few dozen megawatts.

With vistemboirs, control valves are finally subdued!

More: Chapter 22 - Control valves. From chaos to calm.
4.3 Safety Valves

A Mach number of 5, or a flow speed of approximately 700 m/s, appears locally at Denis Papin’s safety valve release.

In this photograph of the memorial statue of Denis Papin located in the courtyard of CNAM the supersonic jet escaping from his safety valve has been inserted, by photomontage (Calculations conducted by EDF-DER for the bicentennial of the CNAM).

Note the expansion of the free jet at the release.

From Papin’s times to today, valves have undergone numerous changes that have been significant because of the effects on flow.

One of main changes has been the implementation of a collector to allow recovery of the released fluid. All the motive power contained in the fluid, which previously released into the surrounding environment, is now forced to dissipate in the reduced space of this collector.

The flow is thereby greatly obstructed by the confined space to later expand downstream. The fluid jet will manage to degrade its motive power to its own interest, fancy, and whims, without worrying in the least about our safety, our environment or our installations.

These safety valves no longer provide satisfactory protection.

More: Chapter 9 - Applied Thermodynamics
Chapter 10 - Jumping the sound barrier
Chapter 23 - Towards calm in safety valves
4.4 The Entropic Vistemboir

Application to Safety Valves

Configuration Composed of Vistemboirs Reduces Instabilities.

The significant difference in pressure that exists between the equipment we want to protect and the reservoir downstream creates considerable flow speed, whose mechanical effects on the structures are poorly understood.

The motive power of the fluid jet for a middle-range industrial safety valve is approximately 10,000 kW.
5 Some Incidents ... Among Others

Gas Turbine Division - The American Society of Mechanical Engineers (September 1986)

“Recently we have been working on a problem involving damage to a 600 MW steam turbine in a coal-fixed power station near Sioux City, Iowa. We have visited the station at several times and as a result I have become better acquainted with the installation and operation of the four control valves for the turbines. The turbine damage is now the subject of a trial in a court of law so I could not discuss it ...”

Aircraft Carrier Charles-de-Gaulle (January 2010)

The French Navy announced that a safety valve had to be replaced and estimated that the job would take several weeks. A malfunctioning was brought to light and the decision was taken to proceed with a standard valve exchange.

Mihama 2 (December 2011) Mihama 2 plant in Fukui prefecture shut down today due to a coolant leak. A valve to adjust the pressure of primary coolant was cited as the problem.

And so on, all over the world.
6 The Invention of the Vistemboir: History, Opinion and Testimony

- **Defense of Doctor of Science thesis** (Université Pierre et Marie Curie Paris VI) in 1984
  "Contribution à l’étude des instabilités d’écoulement dans les organes de réglage."
  [Contribution to the Study of Flow Instabilities in Regulating Systems]

- **Patent registered in 1984.** Issued in 1986 (France 84/03.206); in 1987(USA 4,688,755), in 1988(USA 4,735,224) (Europe 0.156.672), in 1989(URSS 1.450.759) (Canada 1.249.762) Japan(60/39.002)

- Paper presentation at American Society of Mechanical Engineers, Portland, Oregon, 1986

- **American Society of Mechanical Engineers to Directeur General du CETIM**
  "This past October, Dr. Michel Pluviose of your organization presented an excellent technical paper entitled "Stabilization of Flow through Control Valves" at the Joint Power Generation Conference held in Portland, Oregon. Please convey our congratulations and thanks to Dr. Pluviose for his efforts in preparing the paper and making a lucid presentation. The paper’s contribution was original and added significantly to the value of the technical sessions..."  
  
  
  Nagraj R. Eleswarapu, Session Chairman (1986)

- **What one industry insider has to say:** Dresser-Rand (1991)
  "The ASME Transactions of Oct. 1989 contained a 5-page paper by M.Pluviose titled "Stabilization of Flow through Steam Turbine Control Valves". This paper generated considerable interest at Dresser-Rand since we were at that time, trying to eliminate valve instability on a recently commissioned, inner-barrel machine in Korea."
  
  That such highly-regarded industrialists have recognized the driving concepts behind the previously mentioned patents and have applied them is reassuring. We can therefore hope that next generation thermal, solar or nuclear power plants will be equipped with these helpful vistemboirs.

- **What a leading scientist has to say:**
  "It is to his credit that Michel Pluviose has - as the first in the world - not only found solutions, but has also come up with ideas that are based on well thought out, meticulous experiments that allow comprehension and the design of different variants."
  
  Robert Legendre, Haut Conseiller scientifique at l’ONERA², Member of the French Academy of Sciences.

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¹Centre Technique des Industries Mécaniques
²Office national d’Etudes et de Recherches Aéronautiques. The French Aerospace Lab
This book demonstrates that in passing from the principle of least action to the principle of worst action in order to protect lives, physics takes on aspects of philosophy.

Why organize disorder? Is it a provocation? No, it’s an innovation!

An area of physics that could be called degradative thermodynamics, has remained in the shadows. Incomplete understanding of flows possessing appreciable motive power has led to serious incidents and considerable damages.

In some facilities, potentially dangerous flows must be subdued using kinetic energy degraders, which lead to massive but organized disorder, thereby protecting individuals nearby, their installations and their environment.

Degradative thermodynamics presents a new area in the field of non-equilibrium thermodynamics.

In this book, we revisit chaos theory with its fractals and strange attractors so as to escape from chaos and dissipative structures as quickly as possible. We prove that order, chaos, and organization are still powerful drivers in the physical and social sciences.
Cher Monsieur,

Je ne sais si je vous ai remercié de m'avoir adressé votre remarquable ouvrage "L'organisation du désordre. Pour sortir du chaos."

Profitant des semaines d'été, je m'y suis plongé avec d'autant plus d'intérêt que nos problématiques sont proches.

Avec mon meilleur souvenir.

Alain CARPENTIER

Dear Sir,

I do not know if I thanked you for your remarkable book: "Organizing disorder to avoid chaos".

Benefitting of the weeks of summer, I plunged myself in with all the more of interest that our problems are closer.

[...]

Signed: Alain Carpentier,

President of the French Academy of Sciences.
Organizing disorder to avoid chaos

8 Organizations and Affiliations
8.1 The Author

Michel Pluviose is Honorary Professor of Le Conservatoire National des Arts et Métiers (CNAM), and formerly Chair of Turbomachines who received his Doctor of Sciences from Université Pierre et Marie Curie - Paris VI.

A hands-on engineer, Dr Pluviose has worked with leading institutions, including as an engineer at Hispano-Suiza, SNECMA, Head of the laboratory at ATTAG, Manager for compressible fluid activities at CETIM, and engineering consultant in energetics.

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