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Micro versus macro

I read the article "A New Wave of Microfluidic Devices" (August/September, pp. 14–17) with great interest. Fluidic circuits were investigated in the 1960s as an alternative to electronic devices such as vacuum tubes and solid-state devices. In the 1970s, I participated in an effort to develop fluidic diodes and flip-flop devices based on the Coanda effect, that is, the tendency of a fluid jet to follow an adjacent curved surface.

I wish to point out that the crucial difference between macro- and microfluidics is in the use of Newtonian and non-Newtonian fluids as the working medium. Newtonian fluids are characterized by a linear relationship between shear stress and strain (deformation) of the fluid. The miniaturization of devices based on Newtonian fluids was rendered impossible by the high pressures needed to drive these devices to display the kind of highly nonlinear behavior required of them to be of practical use.

Non-Newtonian fluids—characterized by a nonlinear relationship between stress and strain—are now being used to develop miniature fluidic devices, not only for biochemical applications as reported in the TIP article, but also in logic and memory applications analogous to electronic circuits. Readers of TIP will also enjoy the article "Microfluidic memory and control devices," by Alex Grossman et al., *Science* **2003**, *300*, 955–958.

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Neutron generators

The article by David L. Chichester and James D. Simpson "Compact accelerator neutron generators" (December 2003/January 2004, pp. 22–25) describes the conventional sealed-tube beam-on-solid-target type of neutron generator, but it ignores two other newer neutron-generator technologies that are easy to find on the Web.

One is a family of devices from the Lawrence Berkeley National Laboratory (LBNL). Some of these devices have been built as laboratory-level development prototypes and are the basis of several papers published in physics journals. The principle of operation can be reduced to saying that deuterons are extracted and accelerated onto a solid target that is arranged in different configurations, depending on the topology of the neutron generator. LBNL is trying to find a commercial enterprise to invest in the substantial effort to bring these gadgets to market.

The other neutron generator has been developed as a purely commercial market-ready product by a start-up company operating from the United Kingdom and Germany called Neutron Systems Development (NSD) Ltd. (www.neutrons.biz). This generator derives from inertial electrostatic confinement (IEC) fusion research. The commercialization effort started in the mid-1990s, when a major

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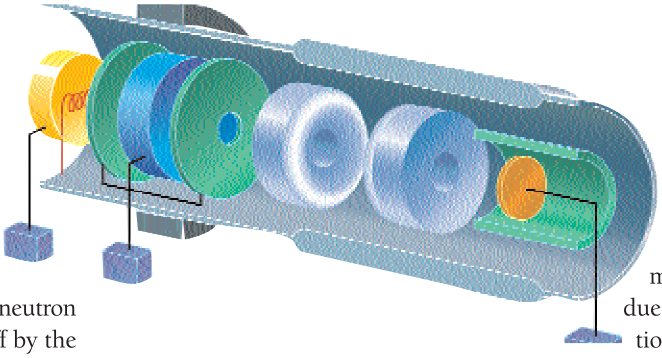

European aerospace company adopted it at a time when non-core business initiatives were encouraged. Like some of the conventional neutron generators, it was eventually cast off by the parent corporation. In this case, the project was reborn as an independent start-up business with its own intellectual property. One difference between this and other technologies is that it has no solid target to sputter-erode. While the longevity of conventional sealed-tube devices has been extended from 500 h to a range of 3,000–4,000 h for certain beam/solid-target sealed neutron generators, the prototype commercial IEC device reached 7,000 h before upper management effectively axed the business. Another difference is that the neutron source geometry can be provided as a line source or a conventional pointlike source.

The elevated concern for security screening technology has created a market for neutron generators ordered in quantity long hoped for by the manufacturers of neutron-based screening systems. Unfortunately, general industrial usage has been inhibited by the relatively short life and consequential unattractive life-cycle costs as compared to ^{252}Cf sources. The availability from NSD of the line-source neutron generator, with a lifetime measured in years, will soon change the market. Although this writer is a director of NSD and is therefore biased, it is lamentable that the editors of *The Industrial Physicist* did not check that the article was complete in its coverage, if not impartial.

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[*Authors reply*: Of course, there are many different ways to produce neutrons besides the one described in our article. Unfortunately, because of space constraints, we had to cut from our original submission a discussion of next-generation neutron generators. Among these are accelerator designs based on radio-frequency (RF) ion sources and systems using the IEC approach.

The RF systems are particularly interesting for industrial applications because of their small size and high potential neutron yields (>1 × 10^{12} neutrons/s). However, despite the exciting promise of RF-based systems, they have not yet seen widespread commercial use. For the most part, this is not due to technical problems associated with the approach, but simply because the final step of commercialization has not yet been taken.

A somewhat different situation exists for neutron generator systems based on the IEC technique. Although a great deal of research effort has been focused on these systems, specifically toward their development for industrial applications, their commercial success has been disappointing. Despite the development of prototype commercial IEC neutron generators and some laboratory and field trials, these systems have not yet found commercial acceptance as an industrial technology. This is witnessed to, in part, by the actions of the technology's previous owner in canceling its IEC development program a few years ago. It is difficult to pinpoint the reason that this approach has not matured further, but it may be partly due to the absence of specific information on performance, including operating lifetime and costs, serviceability, system reliability (in the real world, outside the laboratory), and performance stability over time in the face of changing ambient conditions. In some cases, the large size and power consumption of these systems in comparison with compact-accelerator-based neutron generators may also be a contributing factor.

We regret that we could not describe in more detail the prospects for future compact-accelerator neutron generators and other interesting devices for producing neutrons, such as the IEC line source. However, as in any article for publication, there must be a focus to avoid exceeding reasonable burdens on the editor or the reader. In our case, we chose to focus on systems presently suitable for commercial use and some of their industrial applications.]

Electric grid

Eric Lerner's article ("What's Wrong with the Electric Grid?" October/November, pp. 8–13) did a good job of documenting the situation and commenting on the failure, but I did not find the cause of the failure in the article. Quite simply, the control components and logic are dynamically unstable. The automatic trip levels are too slow and set wrong, and, when they do trip, their action is not continued in a manner that promotes stability. You will always be able to overload a system, but that should not result in shutting down much more than the overloaded area. When you overload and lose the whole system, you have unqualified people responsible for your control dynamics.

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Why have I not seen such a clear and excellent explanation before? The level of writing is surely not more technical than in *The New York Times* science section, where one might expect to have seen this story spelled out already.

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I would expect a news item published in *The Industrial Physicist* to get at least the basic physics right. This was not the case with the political diatribe masquerading as the technical article "What's Wrong with the Electric Grid?" Heat builds up in generator bearings due to underspeed operation? Only generators can produce reactive power? It is true that deregulation, as it has been implemented in the United States, has not adequately considered the operation of the electric transmission system. It does not follow that deregulation is inherently bad. There are good arguments on both sides of the deregulation issue, but this article does not address them.

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The important milestone in the history of the North American grid is deregulation—not the blackout. Your article makes it clear that blackouts are the inevitable outcome of uninformed changes in the factors that affect interruptions in the grid. And there may be other problems as an outcome of utility companies, formerly the willing guardians of the "system," being forced to play a complicated game with insufficient means.

I have a long history with Pacific Gas & Electric. The company did a fantastic job of providing reliable, inexpensive gas and electrical service. And if a kid was missing or someone needed help, its employees were likely to drop everything and lend a hand. That is something you won't see much of in the future. The little contractors providing power and worrying about losing slim profits are not likely to applaud the work of their crews in some community effort they were not authorized to support.

Had your article been published before deregulation, it could have shed some light on issues that needed to be resolved before the old barriers were removed—before deregulation caused the wholesale loss of talent in the oversight of electric transmission.

The conditions that cost me my job with the utility company are the same as those that continue to challenge our grid/interconnect. I couldn't believe the feds would mess with the transmission and distribution system. I watched helplessly as it happened right in front of me.

Many thanks to Eric J. Lerner for writing an overall explanation that can be understood by the lay person without being oversimplified and misleading. The scientists and engineers I worked with would have had a hard time ignoring the truth if this article had been available to read and share with others at that time. I only wish someone had gotten this information into the heads of the Federal Energy Regulatory Commission before they acted on deregulation.

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[*Eric Lerner replies*: Many of the letters in this and the last issue address the question of how to better match local power supplies to local power needs, in order to reduce the long-distance energy transmission that stresses the grid and contributes to large-scale blackouts. A few points need reemphasis. The changes in the rules controlling utilities that were made in 1996–2000, while called "deregulation," were actually changes in regulations, not reductions in the number of regulations. Eliminating those changes, such as Order 888, which mandated that utilities allow long-distance power wheeling across their lines, would not be "a return to regulation" but a change back to older rules. Eliminating Order 888 would certainly have the effect of greatly cutting back on long-distance energy transmission.

Purely economic incentives that add costs to energy transmission have their own problems. Utilities are not capable, as Bob Strachan proposes (December 2003/January 2004, p. 8), of "owning, buying or leasing unilateral transmission facilities" because electricity does not flow directly from point a to point b but takes every available route. So one utility cannot own all the transmission facilities that its electricity flows over—unless, as in some European countries, a single nationalized utility owns the whole grid.

Until quite recently, nationalized, unified power grids were the rule in Europe and much of the rest of the world, and in general, they delivered highly reliable power at low cost. Another benefit is that such unified nationalized systems also lack incentives for long-distance power transmission.

Economic incentives for reactive power production also pose difficulties, given the single-machine character of the grid. Reactive power is not just needed in certain amounts—it is needed in the right time and place. Utilities that have to provide nearly all the power for their own areas have a huge incentive to supply it when and where needed—they get the full blame if the lights go out. But when long-distance power trading is encouraged, responsibility becomes far more diffuse. Utilities could produce reactive power when most convenient for themselves rather than when needed for the system. Similarly, taxes on long-distance transmission, which already exist in the form of fees paid by utilities to each other, will not prevent overloading lines if utilities find that the prices obtained more than balance the fees.]

Correction

In December 2003/January 2004, "North of the Border," by Dan Fleetwood, p. 27, Figure 2: This work was done at Bell Laboratories in 2000–2001 by Julia Hsu before she moved to Sandia National Laboratories, and it is not the subject of her invited talk at the APS 2004 March meeting. Ω