The Hindrance of Breakthrough Technology

by Dennis L Feucht

Scientific and technological breakthroughs are not always unconditionally good. A wildly successful invention or theory sows the seeds for massive misdirection and stagnation. While accepting the obvious good of a breakthrough, be wary of its long-term ill effects. Some examples from outside electronics will illustrate this before applying it to our own field of endeavors.

A Lesson Of Success From Medicine

When antibiotics were found to have amazing curative powers over infectious diseases, the medical industry climbed on that bandwagon, and other prospective approaches to health maintenance fell by the wayside. This one-track mentality in medicine has become increasingly evident. AMA-pharmaceutical medicine, while still holding the high ground of political power, is being challenged in a variety of ways, both from alternative approaches to health care and from within, as practicing doctors become increasingly exasperated with what has become of their trade. Concurrently, medical training is degenerating into which pills to give for which ailments. Pills may be wonderful at times, but they are certainly not the be-all and end-all of health care.

For a half century, antibiotics and chemicals *seemed* to be the clear road to health progress. Antibiotics *were* a genuine mid-century breakthrough in medicine, and a wide range of medical research efforts were consequently shelved as the new wonder-drugs drew in research talent. Breakthrough technology, such as antibiotics, can be so successful that successive breakthroughs are hindered in the wake of long-standing reputation.

Before the inevitable questions you have been waiting for about electronics are broached, let's dwell a little longer on the nature of *breakthrough hindrance* in medicine involving electricity. One neglected area, due perhaps to the success of antibiotics, involves the discovery of a possible new biological system in vertebrates, an *electrical* system. This is not the electrochemical neural system. It is purely electrical, is nearly static, appears to be related to acupuncture points and meridians, and has been described in a quite readable and fascinating book by a leading researcher, Robert Becker, titled *Cross Currents*. It is readily available through the major book sellers.

Becker was nominated for a Nobel Prize for his work on the role of electric fields in bone healing and the regeneration of limbs and organs in lower life-forms. A salamander can regenerate severed limbs. Across the length of its body is a voltage difference related to this regenerative activity. Nowadays, mainstream medicine is beginning to use low-voltage sources to aid the healing of bone fractures. The voltage polarity across the fracture can either aid or hinder bone growth.

Becker and kindred researchers appear to have made some major discoveries in the relationship of electricity and electromagnetic (EM) fields to biological function. One of the interesting discoveries is a relationship between the earth's magnetic field and biological rhythms in various animals. Another is that high-intensity fields do not have the same biological effect as low-intensity fields at the atomic level in organisms. This work is related to the controversy over safe levels of EM field exposure for humans. Becker argues for lower safe levels than is commonly accepted nowadays. The Russians have also done extensive work in this area. Their safety thresholds are an order of magnitude below U.S. thresholds.

Why does Becker argue for lower levels? At first, it seems counterintuitive that a B-field of say, 500 mT -- a typical value found in power-converter magnetic cores -- would not have more biological effect than a 50 mT field. The widely-accepted cause of biological damage -- thermal heating of tissue -- is not disputed for very intense fields, but that is not the only effect. To see why various experiments confirming other effects might hold in theory, Becker refers readers to the atomic model of electrons orbiting nuclei. To these orbits can be applied the cyclotron equation, derived from the magnetic-field force from the Lorentz equation:

$$\boldsymbol{F_e} = q \cdot \boldsymbol{u} \times \boldsymbol{B}$$

where, $\boldsymbol{u}$ is the orbital velocity of the electron and q is its charge. It is the same physics that applies to magnetic deflection of electron beams in CRTs. The electron moving in the closed circuit of the orbit constitutes a current held in that orbit by a magnetic field density of B, of the nuclear magnetic dipole plus any external field that adds vectorially to it. The magnitude of the centripetal force between electron and nucleus is:

$$F_m = \frac{m \cdot u^2}{r} = m \cdot r \cdot \omega^2$$

where, r is the orbit radius, ω is orbital frequency, and m is electron mass. Equating forces for a stable orbit leads to an orbital frequency of:

$$\omega = \frac{q}{m} \cdot B$$

The coefficient of B is a constant, where q and m are fixed properties of the electron. That leaves B to determine the orbital frequency, which also determines orbital radius and consequently the energy level of the electron. Because of the quantum nature of allowable orbits and energies, a small perturbation in B can cause the electron to change energy states while large influences will not satisfy the quantum requirements. In other words, there is a range of B that is small to which the atom is responsive, while values of B outside that range have no effect. Nuclear magnetic resonance similarly occurs within a range of B which includes an upper limit. Small field intensities thereby have an effect at the atomic level whereas larger fields do not.

This atomic-level argument and associated empirical data have yet to make an impact on the practice of medicine or safety policies in the West. As more is learned about quasistatic electric and magnetic fields in organisms, perhaps another breakthrough like antibiotics will become widely acknowledged. What is interesting about some breakthroughs (potential, or actual) is that their acceptance is hardly ever immediate. It takes time for large numbers of people to undergo changes in their conceptual frameworks, even within the specialized groups of experts in the field of the breakthrough. Becker's work has been published since at least the 1980s.

Breakthrough Hindrance In Electronics

As electronics engineers, can we benefit from the example of breakthrough hindrance in medicine? In consideration of breakthroughs in electronics, the transistor has got to be the first that comes to mind. Others would include the laser, some extraordinary circuits (such as those of

Barry Gilbert's translinear concept), the op amp, ICs, and possibly the microcomputer, though it is a combination of two breakthroughs: circuit integration and Von Neumann computing architecture. Microwave devices should also be included, such as the Klystron.

Solid-state electronics has clearly come to dominate electronics as we now know it. It has almost completely obsoleted thermionic valves (vacuum tubes), except in CRTs (which are becoming obsolete), microwave devices, and among audiophiles. Yet in the early 20th century, when thermionic valves were the breakthrough of the era, semiconductor research was also in its early phase. Galena crystals were known to act as primitive rectifiers, useful for building simple AM radio receivers. Julius E. Lilienfeld (1881 - 1963) invented in the late 1920s what is essentially a crude form of MOSFET. (Amplifier for electric currents, US Patent 1,877,140, 13SEP32) Semiconductors were under study. When the triode appeared, it was such an obvious advance that massive efforts were placed into the development of this breakthrough technology, to the neglect of solid-state devices.

Transistors finally caught on in the 1950s, with their emergence from Bell Labs. So successful has solid-state electronics been, that a half century later, unlike antibiotics, there are hardly any contenders with the transistor. Perhaps new forms of transistors -- organic, or carbon-based -- will take over in time, but they are variations on the theme. More radically, nanometer-sized molecular devices might replace what electronics does now. It takes less time to rotate an atom than for an electron to change energy states, making mechanical computation ultimately faster than the prevailing electronic implementations.

Is solid-state just a passing phase? Will electronics return to variations on eclipsed technologies? Thermionic valves are unattractive as active devices because they require the high power of a heater for each valve. But thermionic effects can occur at lower temperatures if the cathode and plate (corresponding to source and drain for post-tube-era readers) are separated by 100 nm. This can be achieved using semiconductor processing techniques. At a closer distance of 10 nm, quantum tunneling occurs -- another achievable technology with breakthrough potential. At a larger scale than molecular mechanics (popularly called *nanotechnology*, another obscure label like "vacuum tube"), Analog Devices, Inc and other semiconductor fabricators produce acceleration sensors, both translational and rotational. Other micro-mechanical devices, such as micro-mirror deflectors made by TI, are coming to market, but if these are breakthrough technologies, they have yet to demonstrate their potential. They do not yet appear to be novel in a way that is also novel.

Molecular mechanics and biotechnology are prospective breakthrough technologies in early development, it appears. Either could eclipse or even obsolete semiconductor electronics. One interesting development is that of http://www.powerchips.gi a pioneering effort to commercialize thermal-to-electrical power conversion using quantum tunneling in devices fabricated using semiconductor processing equipment.

Electronics as a field is overdue for some shaking. In the early years, circuits needed to be understood and new ones discovered. In the 1950s and 1960s this continued with transistors and, with the advent of monolithic integration, the trend has been that of a quantitative shrinkage of geometric scales. Circuit breakthroughs such as the translinear concepts of Barry Gilbert in the 1960s, the bandgap reference of Bob Widler, or the earlier op amp concept, have waned. The emphasis in electronics has shifted to small size, low power, and the continued shrinkage of ICs toward the physical limits. The current dominating trend appears to be that of increasing functional complexity on chips.

Extraordinary Breakthroughs

If the presently emerging technologies are not sufficient to constitute a breakthrough, then electrogravitation has got to be, and illustrates how a well-established theory -- indeed, the very basis of electronics itself, that of electromagnetics (EM) -- might have been hindering larger breakthroughs for over a century. One group of physicists looking for the holy grail of physics -- a unified-force theory -- is taking a direction of both theoretical and engineering exploration that begins with the recovery of Maxwell's EM theory in its original form, as developed around the mid-1800s. Mendel Sachs, a student of Einstein's, proposed a more general theory in the 1980s. A prominent figure in this development nowadays has been Tom Bearden (http://www.cheniere.org), who in a webpage on his site, called "Extraordinary Physics," outlines the possibilities of where 20th-century physics might have been led away from a truly major advance. He argues that the basis for a unified theory was latent in Maxwell's original formulation of EM, based on quaternions, not vectors. Sachs uses spinors and quaternions in his development. A quaternion is a vector plus a scalar, and the scalar is the key, Bearden says, to the unification of gravity and EM. Bearden, the promoter, writes (excerpted from the cited webpage, with original emphasis):

> Well after Maxwell's death, Oliver Heaviside helped to finalize what is today vector analysis. Then he undertook to "translate" Maxwell's theory from quaternion form to the new vector mathematics form. Now quaternions were devilishly difficult to calculate in. So much so, that a majority of the electrical scientists (there were not very many of them in those days!) were in despair. Not to worry! Heaviside took a broadax, figuratively speaking, and simply chopped off the scalar term, leaving only the vector components. With that artifice, he greatly simplified the calculations to be performed. Of course, he also threw away the EM stress of spacetime! That is, he threw away the "gravitation" part of Maxwell's theory! Let me stress this fact most strongly. **After Maxwell's death a single man -- Oliver Heaviside -- directly altered Maxwell's equations, eliminating localized electrogravitation and producing the form of the theory taught throughout the West today as "Maxwell's theory."** Maxwell's theory has never been taught in Western universities! Only Heaviside's crippled subset of the theory has been taught!

The additional quaternion scalar can account for something there (localized space-time curvature, energy stress in the quantum vacuum) when the net vector sum is zero. Bearden makes two points:

> First, we note that, according to general relativity, the "gravitational potential" is just a conglomerate of potentials of all kinds. Basically, a potential represents a G-potential, and consequently a curvature of spacetime. The potential also represents "trapped energy." Second, we note that Kaluza combined electromagnetics and gravitation as a unified theory in 1921. Kaluza added a fifth (spatial) dimension to Minkowski's 4-space, and applied Einstein's relativity theory to 5 dimensions. To Kaluza's delight, a common 5-d potential [accounts for] both electromagnetic field and gravitational field. The [component] of this 5-potential in the 5th dimension (which is wrapped **around** each point in our 3-space) is what we know as the **electromagnetic force field.** The [component] of this 5-potential *in and through* our 3-space is what we know as the **gravitational force field.**

In other words, a theoretical basis in modern physics has existed for some time, Bearden claims, for relating electromagnetism and gravity in a unified theory whereby gravity becomes a component of EM.

Bearden considers that the simplification of Maxwell's original theory by Oliver Heaviside into the less general (but mathematically simpler) four equations that field textbooks attribute to Maxwell led Einstein to formulate his general relativity theory without the benefit of the electrogravitation latent in Maxwell's quaternion-based theory. As Bearden surmises:

> If Einstein had had electromagnetic theory in quaternions, the scalar "vacuum pressure" parts would have been there for him to ponder. It is highly probable that he would have captured the "electromagnetics-to-gravity conversion remainder" in the quaternion interactions.

And further:

> …the quaternion approach captures the ability to utilize electromagnetics and produce local curvature of spacetime, in an engineering fashion. Heaviside wrote a subset of Maxwell's theory where this capability is excluded. [Footnote:] Dr Henry Monteith has independently discovered that Maxwell's original quaternion theory was a unified field theory. See his important "Dynamic Gravity and Electromagnetic Processes," in publication.

What happened around the turn of the 20th century that resulted in breakthrough hindrance? Bearden continues with the historical account of classical EM theory:

> Then, shortly before the turn of the century, a short, sharp "debate" erupted in a few journals -- mostly in the journal *Nature*. Only about 30 scientists took part in the "debate." It wasn't really much of a debate! The vectorists simply steam-rolled right over the remaining quaternionists, sweeping all opposition before them. They simply threw out the remaining vestiges of Maxwell's quaternion theory, and completely adopted Heaviside's interpretation.

A Euroamerican conceit that might also be a factor in the hindrance of a gigantic physics breakthrough, according to Bearden, is not shared globally:

> The [former] Soviets often do not utilize the same restricted kind of general relativity that Western scientists adhere to. Soviet papers in general relativity regularly point out the complete and unrestricted theory, where local spacetime curvature is allowed. They also point out that all conservation laws may be violated by such local curvature. Thus the Soviets have no unduly dogmatic respect for conservation laws.
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> Further, by assuming the possibility of local spacetime curvature, Soviet scientists have assumed the possibility of direct experimentation with general relativity on the laboratory bench. In the West, we have assumed that such cannot possibly be done, because of Einstein's limiting assumption of no local spacetime curvature. Thus Western physicists are strongly conditioned away from electrogravitation.

The Cold War underdog status of the Soviets resulted in a different attitude toward breakthroughs, upon which Bearden (who is a retired intelligence officer with expertise in Soviet military technology) comments:

> After Potsdam and World War II, a frustrated Stalin was to drive his scientists to review the entire scientific literature of the Western world, actively seeking a great new technical breakthrough area such as the Allies had demonstrated with the development and use of the atomic bomb. Great Soviet institutes -- one staffed, for example, with over 2,000 PhDs -- were set up to thoroughly review all the Western scientific literature from its very beginning. Anything interesting, anomalous, or unknown was put aside for further examination.
>
> It is a good bet that the meticulous Soviet scientists discovered the difference between Maxwell's original electromagnetic theory and Heaviside's mutilation of it. Great mathematicians that they are, Soviet scientists would have realized the implications of the

> difference. With their knowledge of unlimited general relativity, they would have made the connection to electrogravitation. By 1950 they had indeed done so, and were deeply into the development of what they called "energetics," and I have called *scalar electromagnetics.*

Could it be that a major breakthrough has already occurred and is as far-removed from ordinary life as nuclear-tipped ICBMs in submarines? One of the difficulties in assessing breakthroughs as they are happening is *whether* they are happening. Extraordinary breakthroughs, such as this one might possibly be, are extraordinary because they strain to fit into the rationale of our present conceptual framework.

The Manhattan Indians, when brought back to New York city after many years, paid no attention to the skyscrapers but were fascinated by a telephone repairman climbing a tree without limbs. Are we scientists and engineers essentially any different when confronted with foundation-challenging ideas? There is ample experimental evidence that EM theory is incomplete. A leading example is the Biefield-Brown effect in which a mysterious force appears across energized capacitors with asymmetrical plates.

Conclusion

What are some maxims about breakthrough hindrance that can be gleaned from these examples? Here is my list:

1. A given breakthrough is not final. Others even greater might be unobservable in the blinding light of the current breakthrough. Only after familiarity has bred some contempt with the given breakthrough might other breakthroughs come to widespread attention and interest.
2. It is often not obvious at first that a breakthrough is occurring, or that a particular direction of research will lead to a larger breakthrough than the current, prevailing one.
3. Others might have discovered breakthroughs that not-invented-here conceits might keep us from appreciating for some time.
4. The subtle but oh-so-reasonable assumptions underlying the foundation of a theory might be limiting it in its range of applicability. We must remind ourselves repeatedly of the old engineering adage: Check your assumptions!
5. The universe is more wonderful and mysterious than our familiar mental habits can account for, and the creative, seeking mind remains open to its possibilities.

Most electronics engineers, even those doing state-of-the-art design, are embedded in the particular problems and challenges of their work and usually do not seek "blue sky" opportunities that lead to breakthroughs. But a few do, and they have names that show up in textbooks and conference talks. The pioneering designer puts sufficient effort into the current project that pays the bills, but has enough vivacity remaining to spend some time on the frontiers, where breakthroughs occur.

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