Inventors and Inventiveness: A Mix of Curiosity, Creativity, Paranoia, Persistence, and Illusions of Wealth

by Christopher King

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"Is there any more feverish dream of glory in the world," writes the novelist and social critic Tom Wolfe, "...than the dream of being an inventor? Certainly not in the United States; and probably not in Japan or any other industrial country.... The inventor needs only one thing, which is as free as the air: a terrific idea."[1]

Of course, in addition to their ideas, successful inventors seem to possess certain essential character traits. Writer Stephen S. Hall, who profiled several accomplished inventors in *Smithsonian* magazine, described the personality "symptoms" as follows: "...energy and persistence; a room-size ego; self-belief bordering on evangelism; justifiable paranoia masquerading as caution; stubbornness and loneliness; a rare and vital gift for visualizing things that did not exist before; a desire to make the world a better place; and, by the by, the desire to make a nice chunk of change."[2] Table 1 is a brief selection of "terrific ideas" that were recognized by induction into the National Inventor's Hall of Fame.

The inventors in the *Smithsonian* article all have stories to share about the trials of getting their ideas to the marketplace, as well as thoughts on the creative impulses

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underlying the act of invention. One of the simplest explanations is offered by inventor Jacob Rabinow, Bethesda, Maryland, who holds more than 200 US patents. "You invent because something bothers you," he told *Smithsonian*. "The more things you play with and the more uninhibited you become, the more likely you are to find a solution."[2]

In 1990, Rabinow published *Inventing for Fun and Profit*, in which he offers his memoirs of life as an engineer, inventor, and entrepreneur—in addition to his thoughts on

Table 1. Inductees into the National Inventor's Hall of Fame—the present to 1979. A=year. B=name of inventor. C=invention.

A	B	C
1988	F.B. Colton	discovery of oral contraceptives
	E.G. Otis	elevator safety mechanism
	L.W. Parker	television receiver
	A. Wang	magnetic pulse controlling device
1987	A.O. Beckman	meter to measure pH
	W.S. Burroughs	calculating machine
	I.I. Sikorsky	operational helicopter
	A.J. Moyer	mass production of penicillin
1986	L. Burbank	plant hybridization
	H.E. Edgerton	stroboscope
	W. Greatbatch	cardiac pacemaker
	E.H. Volwiler & D.L. Tabern	thio-barbituric acid derivatives
1985	M. Camras	magnetic recording
	W.H. Carrier	apparatus for treating air
	W.J. Kolff	soft shell mushroom-shaped heart
	L.M. Moyroud & R.A. Higonnet	photocomposing machine
	R.J. Plunkett	tetrafluoroethylene polymers
1984	W.M. Burton	manufacture of gasoline
	W.H. Carothers	synthesis of acid salts and synthetic fiber
	P.T. Farnsworth	television system
	T.H. Maiman	ruby laser system
1983	E. Alexanderson	high frequency alternator
	A. Alford	localizer antenna system
	H.H. Dow	extraction of bromine
	R.N. Noyce	semiconductor device-and-lead structure
	G.R. Stibitz	complex computer
1982	N.A. Otto	gas motor engine
	H. Ford	transmission mechanism
	J.S. Kilby	miniaturized electronic circuits
	E.O. Lawrence	methodology for acceleration of ions
	O. Mergenthaler	production of printing bars
	M. Tishler	riboflavin and sulfaquinoxaline
1981	L.H. Sarett	treatment of pregnene compounds
	H.S. Black	negative feedback amplifier
	C.F. Carlson	electrophotography
	C.S. Draper	gyroscopic apparatus
1980	E.H. Armstrong	method of receiving high frequency oscillations
	J. Hillier	electron lens correction device
	C.F. Kettering	engine starting devices and ignition system
1979	R.H. Goddard	control mechanism for rocket apparatus
	J.W. Forrester	multicoordinated digital information storage
	C.J. Plank & E.J. Rosinski	catalytic cracking of hydrocarbons with a zeolite catalyst composit

the nature of invention and his advice to aspiring patent-holders.[3] Rabinow made important contributions to ordnance development during World War II, helped to automate the US Postal Service, and tried his hand at marketing a better brand of record turntable—to name but a tiny selection of his endeavors. In his book, he discusses the "inner drive that makes us invent." While the rewards of wealth and fame have much to do with this, there are other inducements. For Rabinow, the respect of his engineering peers, as well as specialists in other fields, is a key motivation. Another gratifying reward for Rabinow, in view of his contributions to the war effort, was the recognition that came from serving his country.[3] (p. 241) Additional recognition comes from the awards conferred by several organizations; Table 2 presents a selection of these.

The motives and characteristics of inventors also have been examined by Robert S. Root-Bernstein, Departments of Natural Science and Physiology, Michigan State University, East Lansing. Considering the differences between invention and discovery, Root-Bernstein observes that "we invent with intention; we discover by surprise."[4] Discussing the characteristics that an innovator might be expected to possess, Root-Bernstein notes, "He (or she) will certainly have mastered the basic tools and operations of the field; he must respect the authority of mankind's inventions;...he is curious; he satisfies his curiosity by seeing for himself if things must be as they are....

Table 2. Selected list of awards presented to inventions and inventors. The name of the award (in bold) is followed by the organization that administers the award.

Concours Lepine
Association des Inventeurs et Fabricants Français
139 rue St. Martin
F-75003 Paris, France

Osterreichischer Staatspreis für Innovation
Austria Ministry of Economic Affairs
Stubenring 1-3
A-1011 Vienna, Austria

Luis Zambrano National Prize for Inventive Technology
National Council for Scientific and Technological Research
Apdo. 70617
Los Ruices
Caracas, Venezuela

Rolex Awards for Enterprise
Rolex Awards for Enterprise
The Secretariat
P.O. Box 178
CH-1211 Geneva 26, Switzerland

Honorary Title of Inventor; and, New Product Award
International Hall of Fame
P.O. Box 450261
Atlanta, GA 30345

Kiwi Awards
Inventors Workshop International Education Foundation
c/o Alan Arthur Tratner
P.O. Box 251
Tarzana, CA 91356

Manning Awards
Ernest C. Manning Awards Foundation
639 Fifth Avenue, SW
Suite 2300
Calgary, Alberta T2P OM9, Canada

Inventor of the Year Award ; and, Charles F. Kettering Award
PTC Research Foundation of the Franklin Pierce Law Center
Two White Street
Concord, NH 03301

National Inventor's Hall of Fame
United States Department of Commerce—Patent and Trademark Office, and the National Council of Patent Law Associations
Crystal Plaza 3, Room 1 DO1
2021 Jefferson Davis Highway
Arlington, VA 22202

In short, he is more interested in problems than in solutions, in processes rather than in products, and in principles rather than facts."[4]

Root-Bernstein also discusses the "global thinking" typically displayed by innovators—a desire, based on a sense that all knowledge is unified, to find general solutions to problems. Lastly, Root-Bernstein mentions two unquantifiable but crucial traits: energy and persistence.[4] Root-Bernstein was featured in a 1989 two-part essay in *Current Contents*® (*CC*®) on art and science.[5] His recent book *Discovering*, which takes the form of a fictional symposium, discusses various aspects of creativity and discovery in science.[6]

Rabinow discusses the process of invention in terms of a search for new combinations. "When one is looking for a solution... one figuratively puts all one's information on cards and throws them up in the air. As the cards hit the floor one looks them over and sees if any of them together, in combination, make sense. Does the combination come up with something that one hasn't thought of—a 'new combination'? The individual items of the information themselves may be quite old."[3] (p. 240)

In their study of two particularly celebrated inventors, Michael E. Gorman, Michigan Technological University, Houghton, and W. Bernard Carlson, University of Virginia, Charlottesville, examine the cognitive processes of Alexander Graham Bell and Thomas Edison in their development of the telephone. Gorman and Carlson see invention as a process in which the inventor combines abstract ideas—"mental models," in their phraseology—with physical objects, or "mechanical representations."[7] As they note, "The strategies and tactics that an inventor uses to bring together mental models and mechanical representations are called *heuristics*.... We believe that an inventor possesses a mental model that incorporates his or her assumptions about how a device might eventually work." Noting that many theories of invention depict a straightforward progression, with the idea followed by the physical manifestation, Gorman and Carlson characterize it as a "recursive activity in which inventors move back and forth between ideas and objects."[7]

Attempting to examine more closely the cognitive underpinnings of creativity and inventiveness, Jonathan Smilansky, School of Education, Hebrew University, Jerusalem, Israel, has performed psychological tests in forming and solving problems. Results in one such experiment supported the notion that a key ingredient in creativity is the ability to *pose*, rather than merely solve, high-level problems. "The concept of intelligence," Smilansky notes, "would then be reserved for the ability to solve problems already created by others."[8]

Observing similar results in a subsequent study, Smilansky and colleague Naftali Halberstadt noted that the ability to invent high-level problems seemed related to the subjects' ability to remain "cognitively independent." This, they concluded, corresponded to the image of an inventor as "a person who is not restricted by the existing solutions" and who conceptualizes "in a manner conducive to developing a new idea or approach."[9]

By Design—Or By Accident

No matter how astute inventors may be, or how innovative their approach, the fact remains that sometimes things simply happen by accident. Or, to use the term more often applied to science and technology, major developments often have resulted from "serendipity" rather than from any deliberate design. As Alexander Kohn recounts in his book *Fortune or Failure*, the word "serendipity" was coined by the English author Horace Walpole in 1754. Basing the term on an old tale known as the "Three Princes of Serendip," Walpole defined that term as "making discoveries by accident and sagacity, of things which [one is] not in quest of."[10] (p. 1) Kohn's book considers some of the "happy and unexpected discoveries" in the history of science, including one of the more celebrated examples: the accidental contamination in 1928 of staphylococci cultures by airborne mold spores in the laboratory of Alexander Fleming, St. Mary's Hospital, London. This serendipitous event, of course, marked the discovery of penicillin.[10] (p. 76-96)

The history of invention features numerous examples of such accidental beginnings. As writer Bob Gatty observes, some of the more popular and ubiquitous inventions of recent times came about through mishaps or unexpected results. For example, that enduring toy known as the Slinky—which every baby-boomer has probably sent walking down the stairs at least once—was inspired when a US Navy engineer watched a torsion spring fall off a table and bounce on the deck of a ship during the vessel's trial run in 1943. The engineer, Richard James, obtained a patent after the war and, after some persistent, do-it-yourself marketing, he and his wife sold the first of what would be millions of Slinkys. Similarly, Post-it Notes, those permanently impermanent little stickies that are such a mainstay of office life, had serendipitous origins in a 3M lab some 20 years ago.[11]

Further examples can be found in the book *Serendipity*, by Royston M. Roberts. In addition to accidental discoveries in science, Roberts discusses the fortuitous development of various commercial products. Nylon, for example, derived from efforts by chemists at DuPont to produce synthetic versions of silk, cellulose, and rubber. Early versions of the material appeared unpromising until one worker noticed that when a bit of the substance was extended away from the main mass, silky filaments were created. The result was underscored during a bit of impulsive experimentation when workers extended strands down a long hallway. Thanks to the accidental discovery of this "cold-drawing" process, the development of an immensely important product was set in motion.[12]

As Gatty notes, other extremely popular products, such as Coca-Cola and Kellogg's Corn Flakes, all derived from instances in which their inventors were looking for something else. The crucial element—as with Fleming and his successors in their development of penicillin—was that these individuals had the inclination and the acuity to recognize the potential in the unexpected

Table 3. Selected list of journals that publish articles on inventors and inventiveness. A=name and publisher of journal. B=first year of publication. C=1988 impact factor.

A	B	C
Bulletin of Science, Technology & Society STS Press University Park, PA	1981	0.021
CHEMTECH American Chemical Society Washington, DC	1970	0.467
Cognitive Psychology Academic Press San Diego, CA	1970	3.000
IIC—International Review of Industrial Property and Copyright Law VCH Publishers New York, NY	1969	N/A
Journal of Creative Behavior Creative Education Foundation, Inc. Buffalo, NY	1967	0.182
New Ideas in Psychology Pergamon Press, Ltd. Oxford, UK	1983	0.136
Policy Sciences Kluwer Academic Publishers Dordrecht, The Netherlands	1970	0.414
Research & Development Cahners Publications Company Denver, CO	1984	0.270
Research Policy Elsevier Science Publishers Amsterdam, The Netherlands	1972	0.531
Research Technology Management Industrial Research Institute, Inc. New York, NY	N/A	0.325
Science, Technology, & Human Values Sage Publications, Inc. Newbury Park, CA	1988	0.702
Scientometrics Elsevier Science Publishers Amsterdam, The Netherlands	1978	0.782
Technology and Culture University of Chicago Press Chicago, IL	1960	0.377

results.[13] Table 3 lists journals that publish articles about the process of invention and the nature of inventiveness.

Pitfalls of the Marketplace

When an inventor manages to bring an idea to practical fruition—whether through dogged perseverance, blind luck, or some combination of both—he or she faces a hard journey on the way to fortune and fame. The first step, usually, is to obtain a patent. In the US, patent law derives from legislation first signed by George Washington in 1790. This first patent bill was intended to protect "any useful art, manufacture, engine, machine, or device, or any improvement thereon not before known or used."[14] (p. 1) Patent laws evolved over the succeeding years, with a particularly important act passed in 1836 that basically set the principles that still apply today.[14] (p. 6)

Today, the conditions under which a patent will be granted are specifically defined. According to the statute, any person who "invents or discovers any new and useful process, machine, manufacture, or composition of matter or any new and useful improvements thereof, may obtain a patent."[14] (p. 3) The subject matter to be patented must be "useful"—that is, it must have a useful purpose and demonstrate "operativeness." In addition to the conditions of novelty and usefulness, the subject matter must also pass a test of nonobviousness, being "sufficiently different from what has been used or described before so that it may be said to be unobvious to a person having ordinary skill in the area of technology related to the invention."[14] (p. 4)

Even with patent in hand, inventors find obstacles. As reporter Rick Wartzman discussed in the *Wall Street Journal*, a major problem is finding the capital to take the idea from model, to prototype, to production. Inventors who've spent thousands of dollars developing their gadgets find that venture capitalists are often reluctant to part with the *hundreds* of thousands necessary to get an invention through testing and production. Simply gaining access to a company to discuss an idea is often impossible, since many businesses fear that inventors might sue them later, claiming that their ideas were stolen.[15] Inventors also can be lured by companies that promise to help them produce and market their inventions. Thousands of dollars later, many inventors find themselves no closer to commercial success.

A more positive and beneficial service can be provided by one of the "innovation eval-

uation" programs being run by a number of universities, small-business development centers, and private firms. For a comparatively modest fee, such programs will offer expert assessment of an invention's technical and commercial feasibility. As is noted by Nancy Bowman-Upton, Center for Entrepreneurship, Baylor University, Waco, Texas, and colleagues, the first such program was begun at the University of Oregon in 1974. Analyzing the benefits and drawbacks of these innovation evaluation programs, the authors conclude that such programs offer a worthwhile service that can stimulate creativity and save inventors from wasted time and effort.[16]

Bowman-Upton and colleagues also note that, on average, no more than 5 to 10 percent of the ideas submitted for evaluation will be commercially feasible. Despite the long odds and the many frustrations, inventors seem to persevere. In his discussion of inventors and their indefatigable zeal, Wolfe recounts several stories of solitary inventors battling huge, well-financed corporations that "ignore patent rights without batting an eye."[1] Such companies are undaunted by the prospect of long, costly litigation, and many inventors must endure endless legal wrangling to protect their rights. "All successful inventors know about depositions," writes Wolfe, referring to the legal documents that record litigants' pretrial testimony; "they learn to live with them the way one learns to live with arthritis."[1]

Studying Patents

Patent laws, as indicated above, have existed in various forms for hundreds of years. In fact, as is noted by Friedrich-Karl Beier, Max Planck Institute for Foreign and International Patent, Copyright, and Competition Law, University of Munich, Germany, the beginnings of "inventors' protection" appeared in the fifteenth century. The Council of the Venetian Republic issued its Inventors' Statute in 1474; this is acknowledged as the first patent statute in the world. As in Venice, inventors' privileges also were issued at about this time in England, The Netherlands, France, and the Holy Roman Empire of the German Nation.[17]

Early patent statistics have provided a wealth of knowledge for those exploring the history of science and technology, as well as such fields as economics.[18-20] My colleague Eugene Garfield has taken a special interest in patents over the years. In a 1966 article originally published in the *Journal of Chemical Documentation*, he discussed "patent citation indexing."[21] He reasoned, as with papers in journals, that the similarity between two citing patents is a function of the common references they share. Therefore, the "references cited" section in US patents could be used as an aid in patent searching. As part of the process of securing a patent, patent examiners, and even inventors themselves, frequently cite the pertinent "prior art"—any previous, related work that may be taken into account when considering an invention's novelty.

For patent attorneys and other interested parties, such lists of cited patents can considerably speed the process of searching for related, relevant material. Thus, the *Science Citation Index®* includes data on cited patents. Garfield's first paper on this subject appeared in the *Journal of the Patent Office Society* in 1956.[22] In that article, he acknowledged the role of Arthur H. Seidell, patent attorney, in first recognizing the need for a patent citator system.[23]

In a 1978 paper, P. Ellis, Kodak Limited, Harrow, UK, and colleagues discussed the use of "patent citation networks" for displaying the history of technological subjects. Examining the development of semisynthetic penicillins, tobacco substitutes, and other technologies, the authors utilized cited patents to create the same kinds of maps of co-cited material that are frequently employed in *CC* essays. Patent citation networks, as the authors concluded, were useful in establishing and displaying the history of a technological subject.[24]

Recently, attention in the US has focused on the percentage of US patents granted to foreign applicants. As was reported in the biweekly newspaper *The Scientist®*, the share of patents held by US firms, individu-

Table 4. Selected list of associations and organizations concerned with inventors and inventiveness.

American Association of Inventors
6562 E. Curtis Road
Bridgeport, MI

American Society of Inventors
P.O. Box 58426
Philadelphia, PA

International Federation of Inventors' Associations
Munkbrou 7
S-111 28 Stockholm, Sweden

Inventors Association of America
P.O. Box 1531
Rancho Cucamonga, CA

International Hall of Fame
P.O. Box 450261
Atlanta, GA

Inventrepreneurs' Forum
Five Riverside Drive
New York, NY

National Inventors Foundation
345 W. Cypress Street
Glendale, CA

Inventors Workshop International Education Foundation
c/o Alan Arthur Tratner
P.O. Box 251
Tarzana, CA

Society for the Encouragement of Research and Invention
P.O. Box 412
100 Summit Avenue
Summit, NJ

US Patent Model Foundation
1331 Pennsylvania Avenue, NW
Washington, DC

World Association of Inventors and Researchers
353, chaussée de St. Job
B-1180 Brussels, Belgium

als, or government agencies has declined in the last 30 years or so—to just over 50 percent in 1988 from 75 percent between 1963 and 1974.[25] This trend was examined in a 1988 paper by Hans H. Glismann and Ernst-Jorgen Horn, Institute for World Economics, Kiel, Germany. The authors concluded that the shrinkage in the US share of patents does not necessarily indicate a decline in research and development activities; rather, evidence seems to indicate that nations such as Japan, West Germany, and the UK have simply caught up with the US in inventive capabilities.[26]

Whither Invention?

Whatever its underlying causes, the slippage in the proportion of US-held patents has occasioned concern in various circles in recent years. Rabinow mentions the decline in science and math curricula in US schools, as well as the general scientific illiteracy that seems prevalent in this country.[3] (p. 260) These themes were discussed in Garfield's two-part 1988 essay on science literacy.[27]

Some observers have pointed to a more fundamental, even spiritual loss of the inventiveness and ingenuity that has long been regarded as an integral part of the American character. In a 1984 *Newsweek* essay, George Galerstein, a patent attorney for Bell Helicopter Textron, lamented the loss of the "mad inventors" who would deluge his office with scribblings and sketches describing visionary schemes for flying airports and airborne paddle-wheelers. While acknowledging that many of these ideas were clearly preposterous, Galerstein intimated that the apparent decline in this breed of dreamers and tinkerers has robbed the American invention scene of some of its vitality and energy.[28]

At least one nonprofit organization has decided to attack the problem at the most immediate and promising level: young people. Begun in 1986 by a retired investment banker and a marketing consultant, a group known as Invent America! sponsored a nationwide invention contest for schoolchildren. Some 30,000 elementary schools participated in the first contest. A sampling of the first batch of entries included a solar-powered heating unit using soda cans to collect heat, a dog collar featuring battery-powered lights, and a "talking" cane for the blind that warns the user of puddles and emits a click when it is accidentally dropped, making it easier to find.[29]

This abundance of youthful interest in invention is certainly encouraging. There also are several societies and organizations, in the US and abroad, dedicated to the advancement of inventiveness and inventors. One of them, in fact, the American Society

of Inventors, is based in Philadelphia. Along with a sampling of other groups, it is listed in Table 4.

Clearly, it is imperative that the spirit of inventiveness be nurtured and encouraged, especially in young women; in the 200-year history of US patents, only 2 percent of the millions issued even mention the name of a woman.[30] Examining the complex variety of factors behind this statistic, such as social training and constraints, environment, and educational opportunities, would easily fill another essay. But the consequence is clear: We have been denied the creative potential of more than half of our population. As we face the problems of dwindling global resources and the growing consequences of our environmental shortsightedness, invention from all segments of our society will no doubt be essential to our survival.

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