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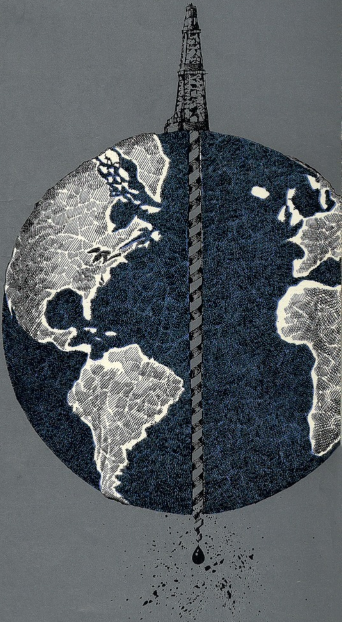


Page 304

Invention and innovation

Surprisingly to many, invention is neither a necessary nor sufficient condition for innovation

David Scott Saari

At the Crystal City offices of the U.S. Patent Office, the inventors of 40 great "new and useful" concepts are honored in the National Inventors Hall of Fame (*2, 3*). A few miles away, patent models (*4*) that once accompanied patent applications for less great inventions are displayed at the Smithsonian Institution. What makes one invention great and another the subject only of nostalgic curiosity? Why have some innovations changed our lives while other attempts have been recorded and then forgotten? This article discusses the significant differences between invention and innovation.

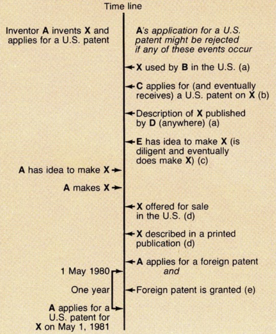
First invention

Patent law (*5*) defines a patentable invention as something that satisfies two important criteria: An invention must be new and it must be useful (*6*).

An invention is "new" according to the law if the invention was not

- previously known or used by someone else in the U.S. before being invented by the patent applicant
- previously patented or described in a printed publication (anywhere) before being invented by the patent applicant
- patented or described in a printed publication (anywhere) or used or offered for sale (in the U.S.) more than one year prior to the date of the application for a patent
- patented in a foreign country prior to the date of an application for a U.S. patent on an application (for the foreign patent) filed more than 12 months before the filing of an application for a U.S. patent
- described in a patent granted on a different inventor's application that was filed in the U.S. prior to the invention of the invention by the patent applicant
- previously invented in the U.S. by someone else who had not abandoned, suppressed, or concealed the invention and who had been diligent in finding a way to make the invention work (reduction to practice) (see Chart) (*7, 8*).

TEMPORAL ASPECTS OF "NEW"

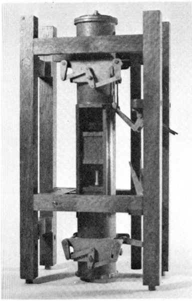


a. 35 U.S.C. 102(a); b. 35 U.S.C. 102(e); c. 35 U.S.C. 102(g); d. 35 U.S.C. 102(b); e. 35 U.S.C. 102(d). (See note 5 for an explanation of the abbreviations.)

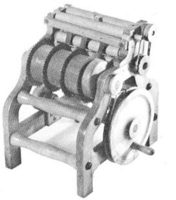
Another aspect of the newness requirement is that the invention must be different from what is called the "prior art," i.e., things known to others in the same field of endeavor (*9*). This doctrine is also known as "nonobviousness." For example, let us suppose that it is common to make wagons and wheelbarrows out of wood held together with nails. A clever wagonwright invents (and receives a patent for) a wooden wagon that is held together with nuts and bolts. Later, this same inventor makes a wheelbarrow with nuts and bolts. The wooden wheelbarrow made with nuts and bolts probably would not be patentable, as the prior art (the patent on the wagon with nuts and bolts in this example) teaches that wheeled labor-saving devices previously made with nails can also be made with nuts and bolts.

An invention is considered "useful" if it works (*10*); things that cannot work according to the laws of science as we presently understand them (i.e., perpetual motion machines) are specifically cited as being unpatentable (*10b*). We may think of things as being useful if those things perform some desirable or beneficial task in a cost-effective way. Except for things that may be considered frivolous or against public policy (*10b*), the only requirements for usefulness under patent law are that the invention be described as being useful for something, and that the invention perform as claimed in the patent application.

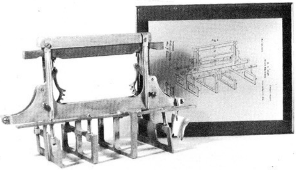
In 1980, the U.S. Patent Office issued nearly 60 000 patents (*11*). Each of the inventions described in these patents was considered by its examiner at the time of issue to be both new (including nonobvious) and useful. Why then are not our lives now being improved in about 60 000 new ways each year? I suspect that the answer lies in the definitions of "new" and "useful." Many inventions may not be useful to us individually, for example, U.S. Patent 4 177 748 for a "Device for Attaching Propulsion Units to a Tabular Iceberg" (*12*). Further, there is a certain quality of newness that is lacking in some of the inventions: Many



U.S. Pat. 235 121 is a model of a hoisting system, issued Dec. 7, 1880, to Z. Blanchet (Photo by Steven M. Hassur)



U.S. Pat. 122 362 is a model of a copper tube cutter, issued Jan. 2, 1872, to J. E. Coffin (Photo by Steven M. Hassur)



U.S. Pat. 149 866 is a model of a brick machine, issued April 21, 1874, to A. H. Keay (Photo by Steven M. Hassur)

patents are issued for improvements (*6*) on that which already exists. For example, U.S. Patent 4 178 879 for a "Restraining Device for Animals" (*13*) describes a "flexible belt member" (collar) having a transparent pouch in which the animal owner may place an identifying address or telephone number. Although the improvement is both new and useful, the effect that the invention has on most of us is not much different than that of the original, unimproved invention, a standard dog collar. Finally, there's the "defensive patent," the one sought to protect one's market to prevent a competitor from circumventing other patented technology the inventor is using. Some inventions are enjoyed for but a brief time; then the invention, like the old patent models at the Smithsonian, will be tucked away to be appreciated only by the scholarly or the curious.

Now to innovation

Occasionally, there are inventions that have a more dramatic effect on our lives (*14*). These inventions change the way that we live. To illustrate, consider the following examples from the National Inventors Hall of Fame:

- Rapid, convenient long-distance communications are a daily activity since Bell's invention of the telephone.
- Auto transportation is beyond a convenience; it's a necessity in modern society, made possible by Otto's "Gas Motor Engine" and Diesel's "Internal Combustion Engine."
- My parents' generation grew up with radio, made possible by Marconi, but my generation has been entertained and educated by Zworykin's "Television System."

In these inventions, the qualities of newness (particularly nonobviousness) and usefulness seem different than those found in the average invention. *These are innovations, new ways of doing something that change the way in which people live.* Why should U.S. Patent 174 465, the telephone, have had such a profound effect on society while U.S. Patent 174 466 for "Combined Rubber Eraser-Holders and Point-Protectors" (*15*) be all but forgotten? I propose that the answer lies in timing and need.

Right time, right place

For an invention to lead to innovation, it must meet each of several criteria. Here are some key ones.

Assume for the sake of this discussion that the telegraph had not been invented in 1832 but that communications technology continued to advance to its present sophistication without it. Now consider the fate of a modern Samuel F. B. Morse faced with the decision whether or not to apply for a patent on an "Electromagnetic Telegraph." Why bother? Who would want to use the Morse concept today? From a modern perspective, the telegraph does not offer many advantages. But when long-distance communications were

On obviousness

Milton said in *Paradise Lost*, in relation to the invention of gunpowder by Satan:

Th' invention all admired
an' each how to be the inventor mised
so easy it seemed once found,
which yet unfound most would have thought
impossible.

U.S. Pat. 18 263 is a model of a cooler (for beer), issued Sept. 22, 1857, to Messinger and Rehahn (Photo by Steven M. Hassur)

no faster than the daily mail, the telegraph was a major advancement in communications technology. One could also envision something having been invented too soon, before the need was there or before it was perceived. Thus Chester Carlson's patent in reprography had nearly expired before the Xerox Corp. (then Haloid) saw its potential. Our point: An invention removed from its temporal environment would appear to have a diminished potential for changing society.

An invention that satisfies a great need will be remembered as a great invention. If it were the nature of human society to be satisfied with a simple life, if there were no desire to travel, to transport goods, to exchange services, to enjoy the fruits of honest labor (or to wage war), then Orville and Wilbur Wright's invention of a "Flying Machine" would be remembered only as an interesting application of scientific principles or as a toy.

An invention that satisfies a fundamental need may also be improved upon by other inventors. Thus a great invention will initiate the development of many other inventions and thus magnify its effect on society. This is the case with the Wrights' invention as with most of the inventions in the Hall of Fame.

One other aspect of timing combined with need is that to have an impact on society, people must ultimately accept the invention and put it to use. If the timing, in the sense of attitudes toward a particular technology or perceptions of a particular need, is not right, then the invention is likely to be forgotten. We probably will never be able to appreciate the changes a given invention could have made but did not because of the temperament of the public at its introduction. Likewise we may only guess at what life would be like now if certain innovations that did change society had not been accepted by society.

The process of innovation

Invention and discovery are the product of an imagination acting upon a collection of scientific principles (*16*). The result is an intellectual creation different from that which existed previously; the creation is new particularly in the sense of being unobvious. But no invention occurs in an intellectual vacuum. For example, an invention in the field of chemical technology must acknowledge the environment of chemical science in which the invention was made (*17*).

In some situations, one may recognize a single invention as being the source of change in society. But more often several creative events, which when considered individually seem to lack the significance of a great invention, contribute to an environment in which change occurs. Taken as a whole, these inventions lead to an innovation equal in stature to any single creative event.

In a sense (and contrary to what was said previously), all inventions are created equal: In a given inventive period all inventions are drawn from the same scientific environment and enter into the same society. What differentiates inventions are the imaginations of the individual inventors, the needs the inventor seeks to satisfy, and the ability of a business entity to fill that need at an accepted price (and sometimes to "create" the need or to alter people's perception of it).

In addition to Goodyear's "Improvement in India-Rubber Fabrics," Hall's "Process of Reducing Aluminum by Electrolysis," Baekeland's "Method of Making Insoluble Products of Phenol and Formaldehyde," Sarett's "Process of Treating Pregnene Compounds," Djerassi's "Δ^4-19-Nor-17 α-ethinylandrosten-17β-ol-3-one and Process," Plank and Rosinski's "Catalytic Cracking of Hydrocarbons with Crystalline Zeolite Catalyst Composite" and Tishler's "Riboflavin" and "Sulfaquinoxaline"—all honored in the National Inventors Hall of Fame—two chemical innovations that have changed our lives are the development of synthetic dyes and pigments, and the invention of xerographic copying. Let's scrutinize them.

Synthetic dyes and pigments. The first use of naturally occurring pigments and dyestuffs is lost in antiquity. Crude pigments were used to decorate the walls of prehistoric cave dwellings. Plant and animal extracts have been used to color textiles and other articles for millennia. Nevertheless, not all dyes are suitable for all materials, nor are the results after extended use always satisfactory. The hue and fastness properties of natural dyestuffs are limited (by modern standards). In this environment of need for new dye materials and at a time when the science of synthetic organic chemistry was developing, Sir William Henry Perkin synthesized aniline purple (mauve) by oxidizing a mixture of aniline and toluidine (*18*). The *Colour Index* (*19*) now catalogs dyes and pigments of almost unending variety, and by comparison Perkin's aniline purple seems insignificant. However, the synthesis of aniline purple initiated the enterprise of dye manufacture and led to the establishment of the dye industry in many nations. The colorful world in which we now live (as indicated by the colored articles, textiles, paints, etc., with which we surround ourselves) has been made colorful by Perkin's efforts and those synthetic and industrial chemists who followed his example.

Reprographics. Imagine a world without the ubiquitous "Xerox machine" (*20*). Rapid communication is the essence of our modern society, and businesses and bureaucracies might cease to function were it not possible to duplicate rapidly the tons of forms, reports, requests, and replies that are the "lifeblood" of commerce and government. Until the "Photomechanical Printing Process and Printing Material for Carrying Out the Same" was developed by André Rott (*21*), duplicates were produced by making a "master" as for mimeographing or by setting type or engraving for printing.

For the first time, copies could be made directly from the original. A later, significant advancement (inducted into the Hall of Fame in 1981) was the development of dry-chemical copying (xerography) by C. F. Carlson. Copying technology developed since Carlson's invention now makes possible reduction, enlargement, the use of untreated papers, and color copying, and illustrates how a seminal patent can generate new generations of inventions.

Perhaps the greatest innovations are not those that influence the quality of life, but rather that affect life itself. These innovations transcend convenience, profit, utility, and the daily affairs of life, and affect our views about our existence and universe. These innovations change our culture.

Obvious examples of great innovations are the developments in the field of nuclear chemistry that led to nuclear power and nuclear weapons. Both technologies from their inception have caused culture-wrenching and occasionally violent differences of opinion. With this technology, we hold the power to supply energy for a comfortable life or the might to destroy the life we now enjoy.

More hopeful examples of great innovations are to be found in the field of pharmaceuticals and the development of "synthetic" substances identical to *Homo sapiens* "natural products."

For centuries, various plant and animal extracts and mineral preparations have been used to relieve distress and to cure disease. More modern innovations are to culture the organisms responsible for the production of the desired agent as, for example, in the isolation of Procaine Penicillin (*22*); to modify the final isolate by introducing an appropriate precursor into the culture medium (*23*); or to induce mutations in the organism with the hope of increasing production of the agent or of changing the chemical identity of that agent (*24*). An alternate (and in this case, earlier) innovation is the synthesis of pharmaceutical substances. Prontosil, 4-[(2,4-diaminophenyl)azo]benzenesulfonamide (*25*), was the first of a series of sulfonamides (the sulfa drugs) to be found to have therapeutic value.

In each of the previous examples, the pharmaceutical agents are "foreign substances" with respect to the host organism, a human being. How different might the medical sciences be (and how different might our society be) if "natural substances," pharmaceuticals identical to the substances produced in the human body, were used to treat discomfort, deficiency, and disease? In some cases, the chemical composition of the human agent is known so that synthesis is theoretically possible, but in most of these cases, synthesis of reasonably pure drugs in useful quantities is impractical. In other cases, near-identical substitutes can be isolated from nonhuman sources (e.g., insulin). But the truly great innovations in this science are occurring in the field of microbial genetic engineering (*24, 26*). By this process, the lowly *Escherichia coli* can be modified to produce human interferon, a potent antiviral agent (*27*), and other human "natural products" (*28*).

Our culture has been changed by many of the innovations discussed in this report, but I do not believe that any invention has the potential for a more dramatic and lasting effect on society than innovations that relate directly to life and the life processes.

Some individuals may propose that the difference between invention and innovation is partially the commercial success of the new item or process. I respond that

First chemical synthesis of 17-hydroxycorticosterone (Kendall's Compound F) was achieved by Merck chemists depicted in this 1951 photo. From left: Drs. Max Tishler, director of developmental research; Norman L. Wendler; Robert E. Jones; and Robert P. Graber

1982 Inductees to The Inventors Hall of Fame

As the nation approached its bicentennial and the American Chemical Society its centennial, the Patent Committee of ACS realized that no chemist had yet been admitted to the Inventors Hall of Fame. Its effort to rectify this situation resulted in the 1976 induction of an American-born and American-trained chemist, Charles Martin Hall, inventor of the process still used today to win aluminum (cf. CHEMTECH, February 1976, p. 83).

This year Hall and the chemists inducted in the last several years were joined by Henry Ford, Jack S. Kilby (cf. CHEMTECH, February 1979, p. 65), Ernest O. Lawrence, Otto Mergenthaler, and—yes—another chemist, Max Tishler.

Chemist, research executive, educator, and inventor, Tishler was born in Boston on Oct. 30, 1906. He graduated from Tufts *magna cum laude* and earned M.A. and Ph.D. degrees in organic chemistry from Harvard.

In 1937 Tishler joined research laboratories of Merck & Co., where his first assignment was to find a new process for the synthesis of riboflavin (vitamin B_2). His success contributed significantly to human health and nutrition and thereby led to processes for the practical synthesis of other vitamins.

Later, Tishler and his associates synthesized and developed a production process for sulfaquinoxaline, the first effective antibiotic for the prevention and cure of poultry disease, coccidiosis. Its use as a feed additive permitted broad expansion of economical poultry production, and added greatly to human nutrition worldwide. Later still he pioneered work on the corticosteroids.

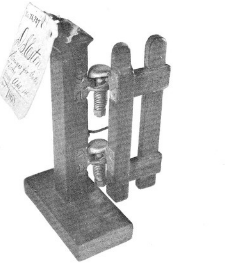
In all, Tishler received more than 100 patents relating to medicinal chemicals, vitamins, and hormones. A former president of ACS, he retired as senior vice president for research and development from Merck in 1969 to become professor of chemistry and subsequently, professor of the sciences, Emeritus at Wesleyan University. He was inducted for his invention Riboflavin Patent No. 2 261 608 dated Nov. 4, 1941, and Sulfaquinoxaline Patent No. 2 404 199 dated July 16, 1946.

Table 1. **U.S. patent applications honored in the National Inventors Hall of Fame**

Name	Title of patent	Date	U.S. patent no.
Witney, E.	Cotton Gin	Mar. 14, 1794	
McCormick, C. H.	Mechanical Reaper	June 21, 1834	
Morse, S. F. B.	Electromagnetic Telegraph	June 20, 1840	1647
Goodyear, C.	Improvement in India-Rubber Fabrics (vulcanization)	June 15, 1844	3633
Pasteur, L.	Brewing Beer and Ale	Jan. 28, 1873	135 245
Bell, A. G.	Telegraphy (telephone)	Mar. 7, 1876	174 465
Edison, T. A.	Electric Lamp	Jan. 27, 1880	223 898
Eastman, G.	Method and Apparatus for Coating Plates Used for Photography	April 13, 1880	226 503
Mergenthaler, O.	Machine for producing printing bars	May 12, 1885	317 828
Mergenthaler, O.	Linotype	May 12, 1885	436 532
Otto, N. A. [assigned to Gas Motoren Fabrik Deutz]	Gas Motor Engine [see also Br. Patent 847, Jan. 19, 1887]	June 28, 1887	365 701
Tesla, N. [one-half interest assigned to C. F. Peck]	Electro-Magnetic Motor	May 1, 1888	381 968
Hall, C. M.	Process of Reducing Aluminum by Electrolysis	April 2, 1889	400 766
Steinmetz, C. P. [assigned to General Electric Co.]	System of Distribution by Alternating Currents	Jan. 29, 1895	533 244
Marconi, G.	Transmitting Electrical Signals	July 13, 1897	586 193
Diesel, R. [assigned to Diesel Motor Co.]	Internal Combustion Engine	Aug. 9, 1898	608 845
Wright, O.; Wright, W.	Flying Machine	May 22, 1906	821 393
de Forest, L. [assigned to de Forest Radio Telephone Co.]	Space Telegraphy (audion amplifier)	Feb. 18, 1908	879 532
Baekeland, L. H.	Method of Making Insoluble Products of Phenol and Formaldehyde	Dec. 7, 1909	942 699
Ford, H.	Transmission mechanism	Oct. 10, 1911	1 005 186
Kettering, C. F. [assigned to Dayton Engineering Laboratories]		Aug. 17, 1915	1 150 523
Kettering, C. F. [assigned to Dayton Engineering Laboratories]	Engine Starting, Lighting, and Ignition System	Feb. 8, 1916	1 171 055
Coolidge, W. D. [assigned to G.E. Co.]	Vacuum Tube (X-ray tube)	Oct. 31, 1916	1 203 495
Amstrong, E. H.	Method of Receiving High-Frequency Oscillations (superheterodyne circuit)	June 8, 1920	1 342 885
Lawrence, E. O.	Method and apparatus for the acceleration of ions	Feb. 20, 1934	1 948 384
Black, H. S. [assigned to Bell Telephone]	Wave Translation System (negative feedback amplifier)	Dec. 21, 1937	2 102 671
Zworykin, V. K. [assigned to Westinghouse Electric and Manufacturing Co.]	Television System	Dec. 20, 1938	2 141 059
Tishler, M.	Riboflavin	Nov. 4, 1941	2 261 608
Carlson, C. F.	Electrophotography (xerography)	Oct. 6, 1942	2 297 691
Goddard, R. H. [one-half interest assigned to Daniel and Florence Guggenheim Foundation]	Control Mechanisms for Rocket Apparatus	April 2, 1946	2 397 657
Tishler, M.	Sulfaquinoxaline	July 16, 1946	2 404 199
Hillier, J. [assigned to Radio Corp. of America]	Electron Lens Correction Device	Dec. 7, 1948	2 455 676
Sarett, L. H. [assigned to Merck and Co.]	Process of Treating Pregnene Compounds (cortisone)	Feb. 22, 1949	2 462 133
Alvarez, L. W. [assigned to U.S.A., Secretary of War]	Radio Distance and Direction Indicator	Aug. 30, 1949	2 480 208
Bardeen, J.; Brattain, W. H. [assigned to Bell Telephone]	Three-Electrode Circuit Element Using Semiconductive Materials (transistor)	Oct. 3, 1950	2 524 035
Shockley, W. [assigned to Bell Telephone]	Circuit Element Utilizing Semiconductive Material (transistor)	Sept. 25, 1951	2 569 347
Land, E. H. [assigned to Polaroid Corp.]	Photographic Product Comprising a Rupturable Container Carrying a Photographic Liquid	Feb. 27, 1951	2 543 181
Fermi, E. [Szilard, L., assigned to U.S. Atomic Energy Commission]	Neutronic Reactor	May 17, 1955	2 708 656
Forrester, J. W. [assigned to Research Corp.]	Multicoordinate Digital Information Storage Device	Feb. 28, 1956	2 736 880
Djerassi, C. [Miramontes, L.; Rosenkranz, G., assigned to Syntex, S.A.]	Δ^4-19-Nor-17α-ethinylandrosten-17β-ol-3-one and Process (oral contraceptives)	May 1, 1956	2 744 122
Draper, C. S. [assigned to Research Corp.]	Gyroscopic Apparatus (internal guidance gyroscope)	July 3, 1956	2 752 790
Townes, C. H.	Production of Electromagnetic Energy (masers)	Mar. 24, 1959	2 879 439
Townes, C. H. [Schawlow, A. L.; assigned to Bell Telephone]	Masers and Masers Communications System	Mar. 22, 1960	2 929 922
Plank, C. J.; Rosinski, E. J. [assigned to Socony Mobil Oil Co.]	Catalytic Cracking of Hydrocarbons with Crystalline Zeolite Catalyst Composite	July 7, 1964	3 140 249
Kilby, J. S.	Miniaturized electronic circuits	June 23, 1964	3 138 743

popularity as measured by commercial success is a natural consequence of the innovation process; in being new, useful, timely, and satisfying a particular need, financial success is justifiably expected.

Many faddish inventions have had great commercial success. These inventions have no special newness or utility to differentiate them from the masses of new things; they are not necessarily timely, nor do they always satisfy a need. Their only advantage is that they are popular (and usually for a limited time); however, their ultimate effect on society is negligible.



U.S. Pat. 76 727 is a model of a gate and door hinge, issued April 14, 1868, to D. S. Eston (Photo by Steven M. Hassur)

Notes and references

(1) Noether, D. L. CHEMTECH **1981**, *11*, OBC, refs. cited therein.
(2) "The National Inventors Hall of Fame was established in 1973 to honor individuals whose inventions, fostered by the U.S. patent system, have prominently enriched our nation's life." (National Inventors Hall of Fame exhibit, U.S. Patent and Trademark Office lobby, Crystal City, Arlington, Va.) Cookfair, A. S. *SciQuest* **1981**, *54*, 28–29.
(3) Inventors and inventions honored in the Hall of Fame (see Table 1).
(4) 35 U.S.C. 114 and 37 CFR 1.91 (see Reference 5 for an explanation of abbreviations).
(5) The present patent law is Title 35 of the U.S. Code (cited, "35 U.S.C."); regulations governing the proceedings of the U.S. Patent and Trademark Office are published in Title 37, Part 1, of the Code of Federal Regulations ("37 CFR 1"). A utility patent (as opposed to a design or plant patent) is a grant "to the patentee, his heirs, or assigns [patents have the attributes of personal property and can be willed, given, or sold to others], for the term of 17 years . . . the right *to exclude* [emphasis mine] others from making, using, or selling the invention throught the U.S., referring to the specification [a detailed description of the invention] for the particulars thereof." (35 U.S.C. 154)
(6) 35 U.S.C. 101. "Manufacture" means a manufactured article. Printed matter, naturally occurring articles, methods of doing business, scientific principles, and some inventions that relate to atomic weapons are not patentable. [U.S. Patent and Trademark Office, "Manual of Patent Examining Procedure," 4th ed., 4th revision, Oct. 1980 (MPEP) sec. 706.03(a) and (b), pp. 132–133.]
(7) 35 U.S.C. 102; the statute has been paraphrased in the article.
(8) This seems like an appropriate place to caution would-be inventors to be careful with regard to their patent rights. The patent laws and regulations should be studied, and the advice of a competent patent agent or attorney may be useful. The U.S. Patent and Trademark Office offers two publications (a single copy is free) that may be useful: "Q & A About Patents" and "General Information Concerning Patents" (write to U.S. Patent and Trademark Office, Washington, D.C. 20231). Another useful publication, "Patents and Inventions—An Information Aid to Inventors," may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(9) 35 U.S.C. 103
(10) a. MPEP 608.01(p), pp. 101–2; b. MPEP 706.03(p), p. 138.
(11) U.S. Department of Commerce, "Commissioner of Patents and Trademarks Annual Report, Fiscal Year 1980"; U.S. Government Printing Office: Washington, Jan. 1981; p. 33; the report covers the period Oct. 1, 1979 to Sept. 30, 1980 (56 618 utility patents were issued in FY 1980).
(12) Mougin, G. L. U.S. Patent 4 177 748, Dec. 11, 1979.
(13) Cunningham, L. B. U.S. Patent 4 178 879, Dec. 18, 1979.
(14) The following publication is an interesting source of information on inventions of historical and technological importance: Pharmaceutical Manufacturers Association, "Story of the United States Patent Office," 4th ed.; U.S. Government Printing Office: Washington, D.C., 1965.
(15) Benson, H. C. U.S. Patent 174 466, May 7, 1876.
(16) Brown, R. A. CHEMTECH **1981**, *11*, 72–76.
(17) The patent rules of practice and examining procedure require that a patent applicant disclose to the Patent and Trademark Office information that may be important to the examination of the patent application (37 CFR 1.56; MPEP 2001, pp. 500.14-.15). Concerning the scientific environment in which the invention is made, the authors of the MPEP suggest that the disclosure contain a description of "the origins of an invention and its point of departure from what was previously known and in the prior art." (MPEP 2004, p. 500.20; cf. 37 CFR 1.97(a) and MPEP 2002.03, p. 500.19)
(18) Perkin, W. H. Brit. Patent 1984, Aug. 26, 1856.
(19) The Society of Dyers and Colourists. "Colour Index," 3rd ed.; 1971, and revised 3rd ed., 1975; the Society of Dyers and Colourists: Bradford, Yorkshire, England; the total number of substances indexed in six volumes is 9091 compounds.
(20) Apologies to 3M, Canon, IBM, Kodak, Minolta, Mita, Nashua, Olivetti, Pitney Bowes, Royal Savin, Saxon, Sharp, et al.
(21) Rott, A. U.S. Patent 2 352 014, June 20, 1944.
(22) Rhodehamel, H. W. U.S. Patent 2 515 898, July 18, 1950.
(23) Behrens, O. K.; Reuben, G. J.; Soper, Q. F. U.S. Patents 2 562 407, 2 562 408, 2 562 409, 2 562 410, 2 562 411, July 31, 1951.
(24) Cape, R. E. CHEMTECH **1979**, *9*, 638–644.
(25) Meitzsch, F.; Klarer, J. U.S. Patent 2 085 037, June 29, 1937; Ger. Patent 607 537, 1935.
(26) Concerning the patentability of "manufactured" microorganisms, see Luberoff, B. J., Ed. "Diamond, Commissioner of Patents and Trademarks vs. Chakrabarty," CHEMTECH **1980**, *10*, 482–487 and MPEP 2105, pp. 500.37–500.38.
(27) See, for example, (a) Nagata, S.; Taira, H.; Hall, A.; Johnsrud, L.; Streuli, M.; Ecsopi, J.; Boll, W.; Cantell, K.; Weissman, C. *Nature (London)* **1980**, *284*, 316–320; (b) Derynck, R.; Remaut, E.; Saman, E.; Stanssens, P.; De Clercq, E.; Content, J.; Fiers, W. *Nature (London)* **1980**, 287, 193–197; (c) Taniguchi, T.; Guarente, L.; Roberts, T. M.; Kimelman, D.; Douhan, J., III; Ptashne, M. *Proc. Nat. Acad. Sci., U.S.A.* **1980**, *79*, 5230–5233.
(28) Riggs, A. D.; Itakura, K.; Crea, R.; Hirose, T.; Kraszewski, A.; Goeddel, D.; Kleid, D.; Yansura, D. G.; Bolivar, F.; Heyneker, H. L. *Recent Prog. Horm. Res.* **1980**, *36*, 261–276.

Photography by Steven M. Hassur

David Scott Saari (1600 S. Joyce St., #A1204, Arlington, Va. 22202; 703-892-4151), recipient of a Ph.D. in synthetic organic chemistry from the University of California, Davis, works at the U.S. EPA Office of Toxic Substances. He is also registered to practice before the U.S. Patent and Trademark Office as a patent agent. When not working on the review of chemicals at the EPA or singing with the Mormon Choir of Washington, D.C., he uses his experience as a synthetic gastronomic chemist to invent new, unusual, and occasionally edible "compositions of matter."

Steven M. Hassur received his Ph.D. from the University of Wisconsin, Madison, and has held postdoctoral positions at both MIT and the Uniformed Services University of the Health Sciences in Bethesda, Md. He is employed at the U.S. EPA Office of Toxic Substances and is involved in the premanufacturing review of new chemicals under TSCA. An avid photographer for over 20 years, he has used his broadly based knowledge in the development of a cameraless technique for recording unstained nucleic acids following gel electrophoresis (UV Shadowing).

Table 1. **U.S. patent applications honored in the National Inventors Hall of Fame**

Name	Title of patent	Date	U.S. patent no.
Witney, E.	Cotton Gin	Mar. 14, 1794	
McCormick, C. H.	Mechanical Reaper	June 21, 1834	
Morse, S. F. B.	Electromagnetic Telegraph	June 20, 1840	1647
Goodyear, C.	Improvement in India-Rubber Fabrics (vulcanization)	June 15, 1844	3633
Pasteur, L.	Brewing Beer and Ale	Jan. 28, 1873	135 245
Bell, A. G.	Telegraphy (telephone)	Mar. 7, 1876	174 465
Edison, T. A.	Electric Lamp	Jan. 27, 1880	223 898
Eastman, G.	Method and Apparatus for Coating Plates Used for Photography	April 13, 1880	226 503
Mergenthaler, O.	Machine for producing printing bars	May 12, 1885	317 828
Mergenthaler, O.	Linotype	May 12, 1885	436 532
Otto, N. A. [assigned to Gas Motoren Fabrik Deutz]	Gas Motor Engine [see also Br. Patent 847, Jan. 19, 1887]	June 28, 1887	365 701
Tesla, N. [one-half interest assigned to C. F. Peck]	Electro-Magnetic Motor	May 1, 1888	381 968
Hall, C. M.	Process of Reducing Aluminum by Electrolysis	April 2, 1889	400 766
Steinmetz, C. P. [assigned to General Electric Co.]	System of Distribution by Alternating Currents	Jan. 29, 1895	533 244
Marconi, G.	Transmitting Electrical Signals	July 13, 1897	586 193
Diesel, R. [assigned to Diesel Motor Co.]	Internal Combustion Engine	Aug. 9, 1898	608 845
Wright, O.; Wright, W.	Flying Machine	May 22, 1906	821 393
de Forest, L. [assigned to de Forest Radio Telephone Co.]	Space Telegraphy (audion amplifier)	Feb. 18, 1908	879 532
Baekeland, L. H.	Method of Making Insoluble Products of Phenol and Formaldehyde	Dec. 7, 1909	942 699
Ford, H.	Transmission mechanism	Oct. 10, 1911	1 005 186
Kettering, C. F. [assigned to Dayton Engineering Laboratories]		Aug. 17, 1915	1 150 523
Kettering, C. F. [assigned to Dayton Engineering Laboratories]	Engine Starting, Lighting, and Ignition System	Feb. 8, 1916	1 171 055
Coolidge, W. D. [assigned to G.E. Co.]	Vacuum Tube (X-ray tube)	Oct. 31, 1916	1 203 495
Amstrong, E. H.	Method of Receiving High-Frequency Oscillations (superheterodyne circuit)	June 8, 1920	1 342 885
Lawrence, E. O.	Method and apparatus for the acceleration of ions	Feb. 20, 1934	1 948 384
Black, H. S. [assigned to Bell Telephone]	Wave Translation System (negative feedback amplifier)	Dec. 21, 1937	2 102 671
Zworykin, V. K. [assigned to Westinghouse Electric and Manufacturing Co.]	Television System	Dec. 20, 1938	2 141 059
Tishler, M.	Riboflavin	Nov. 4, 1941	2 261 608
Carlson, C. F.	Electrophotography (xerography)	Oct. 6, 1942	2 297 691
Goddard, R. H. [one-half interest assigned to Daniel and Florence Guggenheim Foundation]	Control Mechanisms for Rocket Apparatus	April 2, 1946	2 397 657
Tishler, M.	Sulfaquinoxaline	July 16, 1946	2 404 199
Hillier, J. [assigned to Radio Corp. of America]	Electron Lens Correction Device	Dec. 7, 1948	2 455 676
Sarett, L. H. [assigned to Merck and Co.]	Process of Treating Pregnene Compounds (cortisone)	Feb. 22, 1949	2 462 133
Alvarez, L. W. [assigned to U.S.A., Secretary of War]	Radio Distance and Direction Indicator	Aug. 30, 1949	2 480 208
Bardeen, J.; Brattain, W. H. [assigned to Bell Telephone]	Three-Electrode Circuit Element Using Semiconductive Materials (transistor)	Oct. 3, 1950	2 524 035
Shockley, W. [assigned to Bell Telephone]	Circuit Element Utilizing Semiconductive Material (transistor)	Sept. 25, 1951	2 569 347
Land, E. H. [assigned to Polaroid Corp.]	Photographic Product Comprising a Rupturable Container Carrying a Photographic Liquid	Feb. 27, 1951	2 543 181
Fermi, E. [Szilard, L., assigned to U.S. Atomic Energy Commission]	Neutronic Reactor	May 17, 1955	2 708 656
Forrester, J. W. [assigned to Research Corp.]	Multicoordinate Digital Information Storage Device	Feb. 28, 1956	2 736 880
Djerassi, C. [Miramontes, L.; Rosenkranz, G., assigned to Syntex, S.A.]	Δ^4-19-Nor-17α-ethinylandrosten-17β-ol-3-one and Process (oral contraceptives)	May 1, 1956	2 744 122
Draper, C. S. [assigned to Research Corp.]	Gyroscopic Apparatus (internal guidance gyroscope)	July 3, 1956	2 752 790
Townes, C. H.	Production of Electromagnetic Energy (masers)	Mar. 24, 1959	2 879 439
Townes, C. H. [Schawlow, A. L.; assigned to Bell Telephone]	Masers and Masers Communications System	Mar. 22, 1960	2 929 922
Plank, C. J.; Rosinski, E. J. [assigned to Socony Mobil Oil Co.]	Catalytic Cracking of Hydrocarbons with Crystalline Zeolite Catalyst Composite	July 7, 1964	3 140 249
Kilby, J. S.	Miniaturized electronic circuits	June 23, 1964	3 138 743