How Invention Begins: Echoes of Old Voices in the Rise of New Machines

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OXFORD UNIVERSITY PRESS

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Oxford University Press, Inc., publishes works that
further Oxford University's objective of excellence
in research, scholarship, and education.

Oxford New York
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Kuala Lumpur Madrid Melbourne Mexico City Nairobi
New Delhi Shanghai Taipei Toronto

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Argentina Austria Brazil Chile Czech Republic France Greece
Guatemala Hungary Italy Japan Poland Portugal Singapore
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Published by Oxford University Press, Inc.
198 Madison Avenue, New York, NY 10016
www.oup.com

Library of Congress Cataloging-in-Publication Data
Lienhard, John H., 1930–
How invention begins : echoes of old voices
in the rise of new machines / John H. Lienhard.
p. cm. Includes bibliographical references and index.
ISBN-13: 978-0-19-530599-9
ISBN-10: 0-19-530599-X
1. Inventions—History.
I. Title.
T15.L485 2006
609—dc22
2005030825

9 8 7 6 5 4 3 2 1
Printed in the United States of America
on acid-free paper

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Preface

The narrator/ringmaster in the musical *The Fantasticks* begins the show by introducing its characters. Then, as he prepares to put them into action, he utters a wonderful line. "You wonder how these things begin," he says. "Well, this begins in a glen. It begins in a forest where woodchucks woo and vines entwine like lovers."

Beginnings of the important things in our lives are like that. They are quiet and invisible—not like the band-accompanied launching of a ship or the firing of a rocket into space. The ship might have begun with a student sitting on the rocks above the sea, hypnotized by the movement of a boat in the cove below or reading stories of the sea. Perhaps the Saturn rocket can be traced back to a child who watched Fourth of July fireworks, or read about Buck Rogers and Flash Gordon, and then asked, "Why not me?" Invention has fermented alone inside their heads, but it has also been driven by the voices of their communities.

We eventually realize that an elusive a priori essence hovers over all invention; we sense its presence, but it can be fiendishly hard to trace. Too much has always gone on before we get around to assigning priority to the creation of any new thing. Invention is a powerful part of the human psyche. But its texture and form are quite different from the cartoon images that we often use to represent it. We all want to foster the creative improvement of our world, and that alone is reason to spend this time sorting out the meaning of invention.

It is one thing to make the fairly obvious assertion that human invention is ever-present and that it is always accompanied by a communal synergy of ideas. To learn what invention is truly made of, we need to do more than just make that bland assertion. We also need to connect, viscerally, with its seeming contradiction—the coexistence of individual creativity and communal reinforcement. If we fail to ingest the contradiction, we can

easily be tricked by a simplistic reading of the law of the excluded middle—the either/or requirement that disallows multiple explanations for one result.

The fabric of causality becomes terribly complex in the case of invention. That is why we do better if we begin with a seemingly illogical acceptance that invention is the emergence of a collective idea at the same time as it is an expression of one person's genius. Once we make that willing suspension of common sense, we are in a position to start looking for ways that the individual and the community form two facets of a single cause.

To undertake this process, let us spend a certain amount of time on the pathway of anecdote in preference to the straight highway of exposition. I ask you to join me in tracing folklore and history—to play with the mosaic of stories until a picture emerges from scattered tiles. Let us allow invention to reveal itself in very much the same way as it reveals itself to any inventor—by mutating from a jumble of ideas into a whole.

As we pursue this path, we shall (insofar as I am successful) come to better appreciate the vast sequences of invention that produce whole technologies. We see the word *invention* assigned offhandedly to such technologies as the airplane, the steam engine, the printed book, and more. I give away little of my story to say that, at the end, I need to propose a new word to describe these huge aggregates of invention. That way, we can reserve the fine word *invention* for the contributions that we all make repeatedly in daily lives.

Indeed, the aggregation of invention goes beyond even that. For example, we eventually realize that thousands of people applied their corporate inventive genius to something larger than airplanes, railroad engines, or automobiles. A collective desire, an upwelling of fascination and desire, a spirit of the times—a Zeitgeist—laid its hold upon them. The thing that they all sought to create was speed itself.

We likewise can hardly trace the astonishingly complex technology of printing books without coming at last to that which we desire from books—the knowledge, the *learning,* that books provide. Can we speak of speed or education as inventions? I suggest that it is no more of a stretch to do that than it is to call radio or the telephone an invention.

Undertaking these matters has been an ever-opening-up voyage of discovery for me, and so many people have been a huge help along the way. First in any such list must be my wife, Carol, who has read and commented upon draft after draft of each chapter. I am grateful to art and architectural historian Margaret Culbertson, who read the full manuscript and provided a great deal in the way of background advice and sources of illustrations. Medical historian Helen Valier (and her mother) also read the entire manuscript and provided a detailed, and very useful,

commentary. My thanks as well to a large number of people who read and provided advice on selected chapters: Joyce Derlacki, Steven Mintz, James Pipkin, and Andrea Sutcliffe, as well as three anonymous external reviewers.

My thanks to the good people at Oxford University Press: editor Peter Prescott for his ongoing support and cogent advice; his assistant, Kaity Cheng, for so smoothly shepherding the book through the many hurdles of the book-making process; production editor Helen Mules for the grace with which she turns raw copy into this final form; copy editor Sue Warga for her deft touch; and all the other production people who function so effectively in comparative anonymity. I have also extracted more ongoing advice than anyone is entitled to from my generous colleagues: Sara Fishman, Barbara Kemp, Catherine Patterson, Stephen Perkins, and Lewis Wheeler. All these, and too many whom, by failing to keep proper track, I have failed to name have joined in along the way. Finally, my thanks to the fine ongoing support of the staff of the radio station KUHF-FM Houston.

Now I ask you to join me as well. As our *Fantasticks* narrator says, "You wonder how these things begin." Well, since we must begin somewhere, we shall do so high on a mountain crest, 5,300 years ago . . .

January 10, 2006 John H. Lienhard

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Part I

Priority and Apriority

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1

Ötzi and Silent Beginnings

Ötzi slumps against the rock, exhausted. The cold blunts his pain, but only a little. He's ten thousand feet up, on a crest of what you and I call the Ötztaler Alps. For two days, everything has gone terribly wrong. He and two other hunters were looking for deer and wild goats in the mountains when they found they'd trespassed on the turf of a mean band of hunters from another valley. They've been caught in a murderous, drawn-out skirmish ever since.

His forty-six winters make Ötzi the elder of his group. He's a seasoned hunter and a skilled archer, but during their first fight he loosed all his good arrows and was able to retrieve only two of them. One was broken; the other had found its mark. (The man he'd hit was dying when Ötzi pulled it out of his chest.) Now he's left with one good arrow and a quiver of unfinished ones. He'd meant to take care of them along the way, but each night he had been too tired for the work of smoothing the shafts, feathering them, and adding points. It was stupid to venture out here at his advanced age. He's paying a bitter price for overestimating himself.

Worse yet, they killed one of his friends in the fight. He and his other companion were finally able to disengage and run toward the safety of higher ground. Today, they were ambushed by two more of the angry strangers. Ötzi got off one shot—his only shot—but all it did was graze the man in front. The

two closed in, and there was a brief close-quarters knife fight. Ötzi and his friend did enough damage to make them back off, but not without getting badly cut up. Ötzi's hands and torso are slashed and bleeding.

Once more they succeeded in breaking free of the fight. When they took off on the run this time, a strange thing happened. By some crazy logic of chance, Ötzi noticed his one precious arrow on the ground as they ran by. Without thinking, he paused, stooped, and picked it up. That stupid mistake cost him dearly. It made a stationary target of him. As he rose, he caught an arrow near his shoulder.

When they were far enough away to pause for breath, his companion tried to pull it out. But his friend was also hurt, and his fingers were clumsy. The shaft broke loose, leaving the stone point embedded in Ötzi's back. And as they started off once more, his friend stumbled—went down on his knees and doubled over. Only then did Ötzi realize that the fellow had been stabbed in the stomach. Ötzi wrestled him up on his back and set off with the man's arms over his shoulders and his feet bumping the ground. After a few steps, Ötzi felt him go slack. He lowered him to the ground and looked for breath. There was none. His breath had left him.

So now Ötzi is alone and still on the run, that arrow point is festering in his back, and he's up on this high crest, surrounded by only rock and snow. He's a lot higher than he'd ever meant to be. The last of the killers seem to've given up the chase, but Ötzi's exhausted, he's lost blood, and he can hardly move his arm. He calls upon the goddess of the cold moon to get him out of this mess. It's growing colder by the moment, and the terrible pain is giving way to immobility. His arm has become useless. He sinks to the ground. Maybe he can rest for a few breaths and think this through—decide what to do next.

He still has most of his gear—his knife, his clothing, his pack frame. He still has his bow, but only that one good arrow. He has his fine axe with its copper head and its lovingly polished handle of hard yew wood—much good it'll do him now. He's far from home and a serious storm is starting to howl around him. No choice but to wait it out, and he knows it's death to stop moving.

He struggles to stay focused, to keep his mind from drifting back to his village in the valley far below, but he's beset by seductive images of green fields—of warm air, heavy with smells of cow manure, grain, grape, and mint. His imagination, unbidden, flees the pain and tries to summon up the roaring charcoal fire where he smelts copper for his small traffic in axe heads.

The screaming voice of common sense tells him to wake up. Breathe, think, stay alive! But that voice now comes from far down inside some remote cavern of his mind. He feels the pain ebb as his mind finally lets go. He drifts off, no longer hearing the full fury of an ice storm howling

about him. Long before the next sunrise, Ötzi is frozen solid and covered over with snow.

There he remains for 5,300 years. Then, at 1:30 p.m. on Thursday, September 19, 1991, Erika and Helmut Simon, two experienced German mountaineers, on their way down from the Finailspitze, have been lured off their path by the warmth of this particularly beautiful day. This is the warmest summer on record, and here, just south of the Austrian border, on the Italian side of the mountains, they find Ötzi's head and back exposed at last by melting ice.

The Simons have no way of knowing how old he is. A piece of modern ski strapping, lately discarded on the ice above Ötzi, now lies beside him, suggesting that his death was recent. Erika Simon looks at the delicate articulation of his ribs and spine, at the exposed portion of his five-foot-three body, and decides this must be a woman. They both assume they've stumbled across a hiker who died in some accident, maybe a decade or so before. Helmut Simon takes the last photo in his camera, and they hurry down the mountain to an inn where they can report the discovery.

The police are called, and the process of extracting Ötzi from the ice and learning who he really was begins. An astonishing window upon life in the late Stone Age in southern Europe now rapidly opens. That view has improved with each passing year.[1]

One might rightly wonder how much liberty I have taken with Ötzi's story. I would be first to admit that other scenarios might also fit the facts. And as scientists continue sifting the forensic evidence, Ötzi's last days and hours keep becoming clearer. We now know that the point on his one good arrow carries blood from two other humans. Blood from two more people shows up on his knife, and there's more blood on the back of his cloak. The knife blade is flint, not copper like his axe head. It's small with a sharp scalloped blade. Ötzi carried a sophisticated little flaking device to sharpen it.

We've learned that Ötzi had recently eaten vegetables, ibex, deer, and some kind of flatbread. The grains reveal that his home must have been near present-day Bolzano, Italy. Since his hair carries traces of arsenic, a by-product of copper smelting, he most likely did his own smelting and metalwork.

Ötzi overturns so many convictions about chronology. He lived eight hundred years before the Great Pyramid was finished. Until fairly recently, we thought that the most advanced metalworking was that of the Egyptians, who had only begun hammering the occasional metal nugget into useful shapes. We thought that smelting had begun later and that these skills had then taken a long time to reach Europe.

Now we find Ötzi not merely shaping lumps of alluvial metal but actually smelting ore into very pure copper and casting it into useful forms. Ötzi had clearly stepped across the threshold that separates the ages of stone and bronze.

His light gear reflects a remarkable across-the-board knowledge of materials and of means for putting them to use. He used some eighteen kinds of wood and other vegetation to make his clothing and tools. Ötzi and his people were extraordinary technologists by any measure. Take, for example, his shoes.[2]

A Czech shoe technologist, Petr Hlavacek, studied Ötzi's shoes and feet. The shoes proved to be startlingly complex. The leather on the bottom was from a bear and had been cured in a mixture of the bear's brains with fat from its liver. Deer leather formed the tops. The whole array had been mounted on a mesh of braided linden bark and bound together with calf leather. Straw was used for insulation and moss for a lining.

Hlavacek and a colleague made three exact replicas of the shoes, and five more pairs fitted to living people. They used flint to cut the material and bone needles to sew it. Finally, they tested their Stone Age shoes in the snowy mountain terrain during the first spring melt—the time of year when Ötzi died. The shoes served remarkably well. When the hikers waded through snowmelt water, they felt an initial sting of cold, but the inside immediately warmed back up. Traction was excellent, and the shoes offered no opportunity for blisters. Ötzi was, in many ways, better shod 5,300 years ago than you and I are today.

And so, when we meet Ötzi, we feel as though we have broken the seal of a medieval crypt and found an internal combustion engine inside it. Of course it has been said that any good scientific answer generates two new scientific questions. This window into life in the late fourth millennium BC certainly does that. And we're of two minds in our reactions: a part of us wants to follow each emerging question and see where it takes us, but another part of us wants to reach a conclusion.

Whatever you and I know about history, that knowledge probably first took shape when we were schoolchildren. And it is very hard to deal with inconclusive questions in our early classrooms. Teachers suffer constant pressure to traffic in the answers to questions. Very often learning is reduced to the selection of the right answer from a list of four choices. Who is Ötzi? He is: (a) a 5,300-year-old mummified corpse; (b) a villager who looked at the clouds one spring day and deemed it a good time for a hunting trip into the great mountains rising above his valley; (c) a craftsman; (d) brave, cowardly, mystic, rash, a good friend, Italian—or too old at the age of forty-six to be running about in the mountains.

Who can look at Ötzi without aching to know him? The very fact that he lies here, right at hand, makes him frustratingly mysterious. What was

his real name? What did he and his friends talk about? But we want credit for the right answer, so we write down (a) and go on to some other question: When was archery invented? When was copper first smelted? At some point we give up and formulate canonical answers to such questions just to keep from floating away on a great mushy cloud of ambiguity.

So, while others work to learn who Ötzi really was, most of us try to encase his story in some kind of digestible cocoon. Just as we tell one another that Watt invented the steam engine, Edison the lightbulb, Bell the telephone; just as we recite the myths of a Renaissance age of enlightened learning and art and a medieval era of darkness and prejudice; just as we tell children that Washington chopped down the cherry tree, we are equally tempted to fit Ötzi's complex existence into a viable container.

Perhaps that is not all bad. Maybe we need to begin with some framework, no matter how shaky it is. We begin by saying, "America was founded by people seeking religious freedom," and that might not be a bad place to start. Later on, we can sort out the witch hangings or the appropriate roles of church and state. For openers, it might be enough to tell students about the discovery of Ötzi and leave his role as an agent of historical deconstruction for another day.

Deconstruction is, after all, not something we want to undertake for its own sake. On the other hand, sifting out a better understanding of how any new technology came into being includes, by the very nature of the subject, a dimension of pure celebration. Ötzi may be an instrument of historical revision, but (his grisly death notwithstanding) what we've learned about his life leaves me wanting to dance and sing.

Much more is at stake here than revising dates. Rather, it is about seeing our heroes in perspective. For heroes play an important role in our culture. Leslie Brisman begins a study of the origins of Romanticism with a soliloquy on our hero myths. He quotes Rousseau, who said:

> It is no light undertaking to separate what is original from what is artificial in the present nature of man, and to know correctly a state which no longer exists, which perhaps never existed, which probably never will exist, and about which it is nevertheless necessary to have precise notions in order to judge our present state correctly.[3]

Brisman uses Rousseau's analysis to warn us that when the history of our origins has vanished over some now inaccessible horizon, those lingering myths of origins still serve us. Not only do our myths help us to understand ourselves when history has been lost, they also reveal things about ourselves that transcend any existing record of history.

If Rousseau is correct, and I believe he is, we need to pay attention to our myths of invention, even if we have a fairly complete knowledge of our objective history. Something happens when we transform a supposed

seminal inventor into a figure of mythical proportions. The texture of our kinship with the inventor made hero is radically different from our kinship with the inventor as a fellow toiler. Ötzi and Prometheus, taken as exemplars, may ultimately be one and the same, but those two identities serve us in radically different ways.

We meet many heroes in this book. Some are now the stuff of myth, others not. But Ötzi has suddenly surfaced as the oldest technologist known to us, and his corporeal presence forever shields him from being transmuted into mythology. For me, his magic lies in the way his anonymity and his presence merge in a great historical contradiction. He was almost certainly a fine creative technologist. Yet he is without a name, just as you will inevitably be. The flesh and form of his battered body remind us of our own tired bodies. We look at him and we recognize what we see.

A better look at any of our origins through a lens that combines both passion and calculated detachment inevitably brings us back to ourselves. If we understand the texture of past creative accomplishment, we greatly improve our own chances of recognizing and building upon our own unsung efforts to give our children a better world.

Among the impediments to gaining that view is the way we presently describe our technological past, no doubt. But before we can alter our textbooks, we first need to learn just how invention works as a process. The far more basic impediment is the deeply ingrained, and often deceitful, concept of *priority*. Before we travel further with the descendants of Ötzi, we must look at priority itself. Just how has it directed our thinking about human creativity?

We have mentioned the way in which we seem impelled to reduce the cumulative thinking of all the Ötzis who anonymously formed our world down to a few named individuals. Perhaps it is a mere shorthand means for sustaining narrative in the absence of knowledge. Perhaps, too, it is our need to be guided by heroes. Why should it be so hard to identify with the idea of cumulative creative contributions? Yet difficult it is, and if this need for naming individuals did not serve some human function, it would not persist the way it does.

We obviously cannot talk about invention and historical antecedence without first untangling our seemingly atavistic need to credit one individual for the work of many. If we are to talk about how our technologies are brought into being, we need to think first about what I should like to call the invention of priority.

2

The Unrelenting Presence of Priority

The question I am asked most often is, "Who first invented this or that?" I can never seem to give the questioner any proper satisfaction. In fact, I shy away from the question just because I know that, after the conversation has spun around, it will end at last in frustration for both parties.

Perhaps it is worthwhile to place one such question on the table here, so you and I can watch how the search for the answer plays out. Allow me to offer an ostensibly frivolous question, one that is not apt to awaken anyone's passions, but which is actually quite revealing. Let us ask, "Who invented the *doughnut*?"

One person who gets prominent credit is Maine sea captain Hanson Gregory.[1] Gregory's ship was named *Frypan* because he fed his sailors fried cakes. They were deep-fried according to his mother's recipe. A problem with those otherwise delicious cakes was that their centers were often undercooked. In 1847, Gregory punched out the center of a cake so that all the dough that was being cooked lay near the surface. The result was a far more uniformly cooked cake.

That story is often told with embroidery about eating doughnuts during storms at sea, about punching the hole with a belaying pin, and so on. But the problem with Maine's claim is that Massachusetts rises to the challenge with an earlier and far more fanciful tale. According to their account, Indians found a Cape Cod Pilgrim woman deep-frying cakes in an outdoor pot. They decided they could frighten her off by firing an arrow so it would noisily strike the pot. Then they could steal the cakes. But the bowman's aim was high. Just as the woman reached over to put another cake in the pot, the arrow drilled a hole through it. The woman screamed and fled. When she did, she dropped the cake into the oil, and the first doughnut was cooked.

Needless to say, such claims do not end with Maine and Massachusetts. According to Vermonters, their native son Shadrach Gowallapus Hooper invented the doughnut.

If one expects a patent to resolve the question, one gets John Blondell's 1872 patent for a wooden doughnut cutter—hopelessly late in the game. Another cutter was patented in 1891, this one made of tin. But cutter patents do not address the conceptual leap upon which the doughnut rides in the first place. That's the understanding that the cooked surface area per unit volume of dough is improved by a hole.

Naturally, when one looks closely, one finds European antecedents. And Asian cooking includes a deep-fried doughnut called a *vada,* whose dough is made from lentils. Another solution to the problem of cooking a cake uniformly is far cleverer than the doughnut, and very old. The New Orleans beignet and India's poori are only two examples of cakes *hollowed out from the inside* rather than drilled through. In both these cases, steam pressure develops when a small amount of water boils inside the pastry.

The poori and the beignet are both instances in which the motive force of steam is harnessed to do a task. One might even call them antecedents of the steam engine (Chapters 4 and 5) since steam does work in inflating the dough like a balloon. As we sift all the means used to execute this pretty obvious but still ingenious principle, the question of identifiable invention crumbles in our hands like dry leaves.

And this is not because the example was frivolous. The stories surrounding modern machines to which we routinely apply the word *invention* are no different. Invention constantly eludes us by ramification—by stirring and blending with additional ideas. The doughnut/beignet makes a fine exemplar of the norm.

The stories of inventing the steamboat, telegraph, airplane, or lightbulb may be told with a straighter face, but in every case

Top: An Indian vada.
Middle: A New Orleans beignet uncooked on the *left*, and one deep-fried on the *right*.
Bottom: The interior of a freshly cooked beignet, hollowed out by vaporized water.

their structure is similar. We have assigned inventors to each of those technologies, and it might often seem that we did so by tossing the names of people who worked in these technologies into a hat and pulling one out. Fulton, Morse, the Wright brothers, and Edison all made huge contributions that served to consolidate each of their technologies. But to call any of them a primary inventor of their technology is a little like naming the inventor of the first doughnut hole.

The culprit here is that word *naming*. So let us take a moment to weigh priority in relation to naming. Naming is, after all, a near-mystical expression of power. The book of Genesis offers a very important suggestion of the power of naming, right at the beginning. In Chapter 2 of Genesis we read:

> And out of the ground the Lord God formed every beast of the field, and every fowl of the air; and brought them unto Adam to see what he would call them: and whatsoever Adam called every living creature, that was the name thereof.

God grants Adam dominion over the creatures. Adam's first expression of that power is the act of naming them.

Overtones of naming reach far beyond mere identification. The rite of baptism carries the idea forward in the Judeo-Christian tradition—the notion that parents are responsible for stipulating the name by which a child will be known to God.

Shakespeare retained all the mystery of naming when he made a direct connection between naming and the creative process. In *A Midsummer Night's Dream,* he puts these familiar, but no less remarkable, words in the mouth of Theseus:

> The poet's eye, in a fine frenzy rolling,
> Doth glance from heaven to earth, from earth to heaven;
> And as imagination bodies forth
> The forms of things unknown, the poet's pen
> Turns them to shapes, and gives to airy nothing
> A local habitation and a name.

To create—to bring a new thing into being—is, in other words, to add a new name to our world.

The power of naming was given an important boost by a primal technology that was emerging at the same time that Ötzi lived. Rudimentary hieroglyphs were appearing in Egypt, far from the Tyrol, in the centuries that bracket Ötzi. Ötzi himself carried some fifty-nine tattoos on his body—all dots or straight lines arranged in abstract groups. These may have had something to do with healing, and in that role it is very likely that they contain information of some sort and are not pure decoration.

In fact, the dating of the first hieroglyphic writing depends, in part, upon what level of pictogram we are willing to accept as having made the leap from art into building blocks of narrative.

Means for recording words and concepts were forming, along with our ability to preserve both the identity and the context of real people. The written record would now provide human identity in perpetuity. The old oral traditions would continue turning remembered people into metaphor. I suppose they still do today. But the written word was a counterbalance. When we created writing, we turned legend into history.

So, who do you suppose the first person in this new written history was? Well, it turns out to be a highly creative inventor! Historian Will Durant offered Imhotep as the first real person who is well enough documented in Egyptian and Greek texts to take on flesh and blood.[2] Beginning with Imhotep, we leave the cardboard figures of legendary kings and patriarchs and encounter a human figure about whom we know some details.

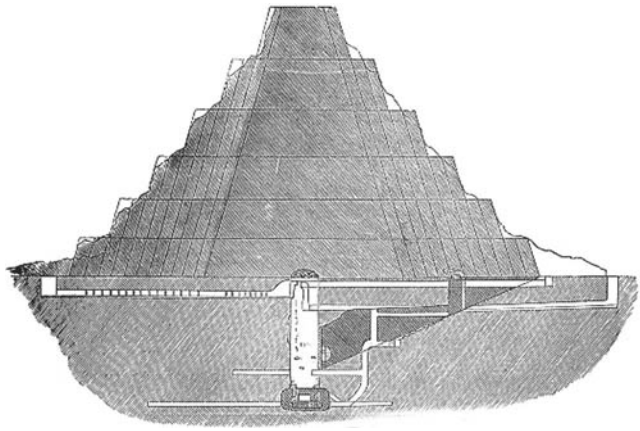
Limestone bas-relief of Imhotep (or Hotepa).

Let us meet this Adam of recorded history. Imhotep was the advisor to the Egyptian king Zoser, who ruled around 2680 BC. Zoser was the dominant king of the Third Dynasty and the first ruler of what we call the Old Kingdom. The Old Kingdom itself is so named because it marks the point at which written records first begin reporting Egyptian history in any detail.

Imhotep was born near Memphis. We even have the names of his parents: Kanufer and Khreduonkh. He was known to be very wise, and he became a minister in Zoser's court—a vizier, chief ritualist, and counselor. He was also an architect. The heroic stone structures of ancient Egypt began under Zoser. Just a few centuries later they would culminate in the Great Pyramid of Khufu at Giza. Writing reveals just enough for us to understand that the force behind all that was not Zoser but Imhotep. Imhotep created a new architectural order.

He oversaw the building of the Stepped Pyramid at Saqqara—the first of the great Egyptian pyramids. It is the oldest of those heroic architectural treasures still standing. The Stepped Pyramid rises like a great wedding cake, and the ruins of what was once a delicate, four-acre, low-lying limestone temple surround it.

Imhotep's architecture is the part of his legacy that looms largest in our minds, because we can still see parts of it, but he was also a writer and a poet. However, his priestly role definitely subsumed medicine at the time. And here the mischief of priority assignment already touches Imhotep. For Egypt honored him more for medicine than for either writing or building.



Cross section of the Stepped Pyramid (from *History of Architecture in All Countries*, 1883).

We have no idea what his medical contributions were, or even if he made any. We know only that the Egyptians eventually deified him for his healing. It is possible that by the sixth century BC Imhotep had displaced the god Toth as the god of healing, and his real father, Kanufer, was replaced with the Memphis god Ptah.

By then, the Greeks had their own god of healing, Asclepios. He too was derived from a real person whom Homer mentioned in the *Iliad* only as a fine physician. As Asclepios was expanded in the oral legends, he (like Imhotep) was deified. He was given Apollo for a father. Finally, Imhotep and Asclepios appear as a single god called Asclepios-Imhoutes. (Perhaps the Greeks were just hedging their bets.)

As a sidebar on all this, you may recognize the name of Imhotep not from any role in history but because his name was, for no particular reason, given to the title character in the 1932 horror movie *The Mummy*. The name Imhotep was resurrected (reanimated?) for the 1999 remake of *The Mummy* and its 2001 sequel, *The Mummy Returns*. And in 2002 we find it again in a bizarre but critically acclaimed comedy, *Bubba Ho-Tep*.

So although we might place the mantle of "first person in recorded history" upon Imhotep, his human person was eventually turned into something else entirely in our minds—god or movie monster, but no longer flesh and blood. History may be the worse for that, but history now existed where it had not existed before. Emerson would eventually write, "There is properly no History; only Biography." After Imhotep, we would have history and we would have biography.

Imhotep reached his bare threshold of history six hundred years after Ötzi was frozen into the Ötztaler Alps. The emergence of individuals as

named historical figures would now mean that an occasional anonymous Ötzi would be turned into a historical figure. In that, the Stone Age did not so much end with the introduction of copper, brass, and iron—rather, it ended with written language. It ended with written names of real people.

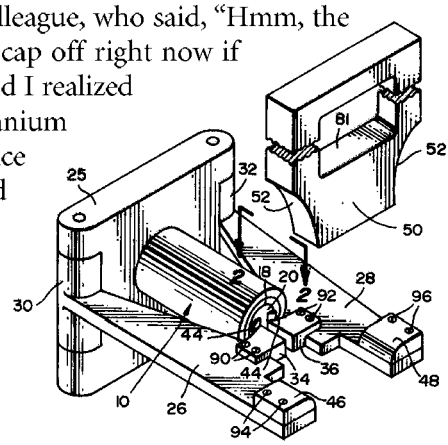
Once we had names and identities, we used them to continue and elaborate the legends of greatness. You, I, and Ötzi all invent, yet none of us is ever really first to produce any technology. Our inventions always build upon antecedents. Why, then, do we buy into the concept of priority? I think the primary purpose for doing so is to celebrate the creative process. That is all well and good, so long as we do not let someone else's canonical greatness intimidate us—make us feel that our own inventive capability is too modest to put to use.

Today, we might expect to find that the linkage between names and inventions is firmly established by our system of patents. Indeed, when questions of priority arise today, all eyes turn to patents. Yet that linkage is far less solid than we might hope. While the concept of priority (shaky as it is) is embedded in patent law, patents are extremely unreliable identifiers of creative priority. Their real function is to sort out ownership in a world that feels it depends upon the ownership of ideas. Patent law has very little to do with the way invention actually works.

Indulge me for a moment while I offer an experience of my own with invention and patents.[3] In the 1970s, under contract with the Electric Power Research Institute (EPRI), I was trying to learn what would happen if a high-pressure hot-water line in a nuclear reactor fractured. The immediate problem was to simulate a pipe break by opening a high-pressure hot-water pipe very rapidly.

The two obvious options were bursting a metal diaphragm or blasting the end of the pipe off with explosives. Unfortunately, diaphragms don't tear fast enough, and tailor-made explosive charges are both messy and expensive.

I mentioned the problem to a colleague, who said, "Hmm, the pressure in that pipe would blow a cap off right now if you could just release it quickly." And I realized that we should be able to design a titanium plug combined with a guillotine device to accomplish a fast release. I sketched out the design for the graduate student who was working on the project, and together we built such an apparatus. With it we managed to drop the pressure in a pipe at the astonishing rate of well over a million atmospheres per second—far



faster than anyone else had ever opened a pressurized pipe. In the end, the results of that work were translated into a part of the nuclear safety codes.

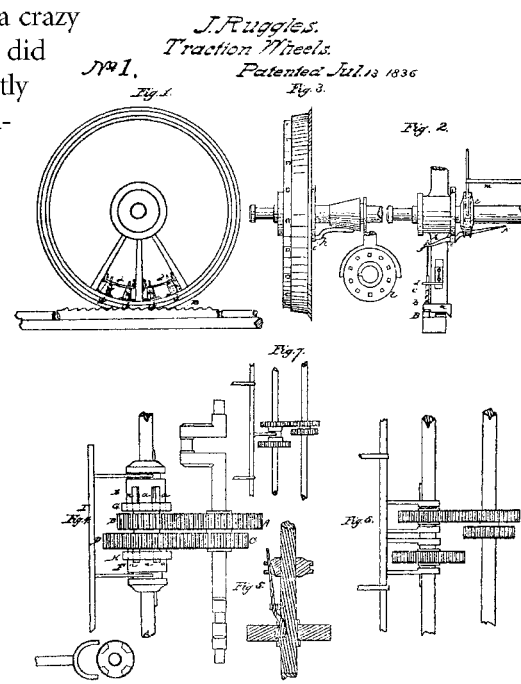
So EPRI filed for a patent on the device. When I saw the finished patent, I was astonished to find that lawyers had made fifteen different claims to creative invention from this one simple gadget.

Now EPRI owned a patent, which contained ideas (suggested by our work) that had never occurred to us. The credited inventors were the student and me. The colleague who had made the remark that triggered the patent in the first place had pretty much forgotten about the passing conversation.

The obvious question of just where what idea came from was now subsumed in the patent, and even as a primary participant, I cannot really claim to understand the precise evolution of the idea(s) now embodied in it. That's because I now understand how impossible it is to accurately parcel out individual credit for any invention. Our opening device was completely typical in being the ultimate result of ongoing communal creative input.

To see just how tenuous the patent is as a representation of priority, suppose I were to tell you that all the patent records over a half century had been suddenly and completely expunged. In that case, any new overlapping patent would have to be issued regardless of duplication. Where would priority go in that case?

Although that may sound like a crazy scenario, it is exactly what really did happen. Our U.S. patents are presently numbered sequentially, with a cumulative number that will reach 7,000,000 in 2006. These patents are issued by an office that opened in 1790, soon after the American Revolution. Yet patent number 1 was not issued until 1837, forty-seven years later.



To see why, let us go back to the War of 1812, when the British burned Washington. The building that then housed the Patent Office and General Post Office was the only government building to survive. Congress met in that old building while the Capitol was built. The existing patents

had survived the fires, and during the next twenty-four years, inventors continued adding to their number.

By 1836, however, the building had become hopelessly outdated and overcrowded. This one original building was now a firetrap and home to ten thousand patents, along with seven thousand patent models. As it threatened to burst its seams, the government finally authorized construction of a new office.

Just then, as if on cue and before construction began, a fire broke out in the old building. The new building had been authorized too late. The old Patent Office had survived the War of 1812, but now it succumbed to a mere accident. The fire destroyed the office and everything in it.

The Patent Office now had to be rebuilt from scratch. Only as the office began anew, did it initiate its present sequential system of numbering patents. Patent number 1 was issued to John Ruggles in 1837. It described an improved railroad wheel, meant to gain better traction.

The office managed to reconstruct two thousand of the ten thousand lost patents during the next decade. They assigned a parallel sequence to the resurrected patents, numbering them as X-1, X-2, and so forth. They attempted to place those numbers in the correct chronological sequence as well, and that has led to an odd complication. When a rediscovered patent is deemed to lie between two adjacent numbers, it is given a fractional value so the sequence will be correct. We've come to call those rebuilt documents the "X-patents."

The yield of lost patents slowed almost to a halt after about a decade. So the Patent Office abandoned active reclamation work, writing off the remaining eight thousand patents as an irretrievable loss of our national legacy.

Others, however, have continued the search. In 2004, *New York Times* writer Sabra Chartrand described the surviving process of patent archaeology.[4] Some eight hundred additional X-patents have been restored since the Patent Office gave them up for lost, and the work goes on. Bit by bit, the record continues to be reconstructed. And the task is being done by the most effective workforce in the world—dedicated amateurs. Some of those "amateurs" are seasoned patent attorneys, but they are doing the work on their own, pro bono.

The trigger for the *Times* article was one discovery in particular, and it is very revealing. Copies of fourteen old patents turned up in the library of Dartmouth College. Ten of them had been donated by Samuel Morey, an important early American inventor.[5] One of Morey's X-patents was already well known, at least in his native New Hampshire. Filed in 1826, it described a gas-driven internal combustion engine. That was long before the Otto cycle and probably it was the first gasoline engine—a stunning example of one of the inventions that undercut our canonical priority assignments.

Much earlier, Morey had patented a steamboat and actually built a working model. Morey tried to sell his X-patent for that one to Robert Livingston, the financier who ultimately backed Robert Fulton. Morey took Livingston for a ride on his boat, but the two could not come to terms on how to arrange the finances or how to divide the potential profits.[6]

When Fulton finally filed his own patent, he emphasized the paddle wheels on his boat. That was a part of Morey's steamboat that (unlike all those claims on my pipe-opener patent) had *not* been included in Morey's patent. The rest, as we say, is history.

Morey's presence among inventors of the X-patents suggests what their true meaning might be. They were written when American invention was still very young. Today, we have seven hundred times as many patents as we did in 1836, but those missing patents, written upon an almost clean slate, have a certain primacy over later ones. They undoubtedly include more potential nuggets of surprise—more treasures (such as pre-Fulton steamboats and pre-Otto internal combustion engines) that have been duplicated during the long years since.

They also dramatize the fact that almost nothing has any one absolute inventor. We recite the name of this or that lonely genius so often that we start believing such a person exists. Yet he is, by and large, a created hero who manifests the many builders of our present world all rolled into one person. He is the hero whom we invent to explain who we now are, in the absence of full knowledge of our past.

Therefore, let us not stop with doughnuts, pipe openers, and the supposed potential of undiscovered X-patents. We need to see how the process of unpriority—of *apriority*—works in our major technologies. We can pick any one out of a thousand, but this time let us begin with a particularly deceptive one.

Very few creations of major technologies trace as convincingly to a particular inventor as the airplane traces to the Wright brothers. But we would be hard-pressed to find another with as many competing claimants. For that reason, the airplane makes a fine place from which we might take a larger look at the strange business of assigning priority.

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