Soul

Copenhagen, Denmark

(freezing)

Yep, definitely in Copenhagen. As I wait to cross the road, a muscular, Lycra-clad Dane scoots past on cross-country skis with wheels attached (the wheels alleviate the lack of snow).

I've been invited to Denmark to teach a design "master class" (their words), and I've arranged my travel via Copenhagen, as I'm going to meet someone who I hope could help me with my elephant project. I'm looking for a place called Ballonparken: a site in central Copenhagen with one hundred small wooden huts, built in the Second World War to house antiaircraft balloons. Now the huts are occupied by a community living as "an independent self-governing institution," serving as homes for individuals wishing to live counter to the prevailing culture. One of those individuals is a shaman, and it is she whom I seek.

My perspective on life has shifted since the melancholy of the introduction. My generalised angst about the world has passed, the argument with my girlfriend is water under the bridge, and my self-indulgent funk has cleared. The fact that I'm referring to an introduction means I sent that writing to Princeton Architectural Press and they've indicated they'll make a book of it, if I can get it together to finish this bloody thing. And if I do, well, "Hullo there, gentle reader!"

And maybe it's just because my phone broke and I can't check the

news every five minutes, but no longer does the world seemed doomed, either. Sure, there's a lot wrong out there, but things are going in the right direction. The gap may be widening, but the poor are still getting less poor; global population will peak in a few years and then decline, and technology will develop so we can all live comfortable and fruitful lives without sending the climate too far out of kilter. Hooray! (And terrorists? Terrorists who? They're just the current crop of terminally misguided bananas, and every generation has its own bunch.)

In short, the world and I are on the up! But while *I'm feeling fine*, the grand project to become an elephant has quietly ground to a halt. Don't tell the Wellcome Trust, but I've pretty much been avoiding it, finding myself pleasantly engaged in other things (like this, ahem, *master* class). You see, a rather fundamental problem has developed with the very premise of this I-want-to-be-an-elephant project, and that is I no longer want to be an elephant.

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I'd decided to become an *elephant* mainly for practical reasons. Somehow, when I was writing my proposal to the Wellcome Trust, the design constraints inherent in becoming an elephant, as opposed to some other nonhuman animal that fitted my vision of roaming free in the landscape, seemed less insurmountable.

This was based on the following assumptions: first, the build envelope of an elephant is rather large, with ample room to contain me inside, as well as negating any need for fiddly microengineering. Second, being big, elephants are slow and lumbering, right? Hence, if my exoskeleton turned out to be slow and lumbering, as I rather suspected it would, no matter. Third and most crucial, my concern was with neck length.

I considered neck length to be so important because while it was easy to imagine extending my arms to become a quadruped, I just couldn't imagine a way to extend my neck to match. And elephants are pretty unique in that they're grazing animals with a short neck relative to their legs.

A fundamental part of being an alive animal is not becoming food for another animal. So to avoid being eaten alive, a set of long and fast legs

can be an advantage. But another fundamental part of being an alive animal is eating food yourself. If you're a herbivorous quadruped, then you eat grass and foliage. This has a low energy density, which means you need to eat a lot of it. In fact, your face needs to be in your food for about 60 percent of your waking life. And since your food is often at your feet, a neck long enough to allow you to get your face down to your food with a minimum of fuss is an advantage.

So to optimise the two advantageous characteristics of speediness and grazing efficiency, evolution has acted through the painful mechanism of animals being eaten alive or starving to death (or some grim combination of the two) to keep the necks of all herbivorous quadrupeds approximately as long as their legs.[1] All, that is, except the elephant. With elephants, evolution took a radically different course: grow the legs (hell, grow the whole frickin' animal if you like!) *and* keep the neck short? You bet: don't move your face to your food; move your food to your face! How? With your nose!

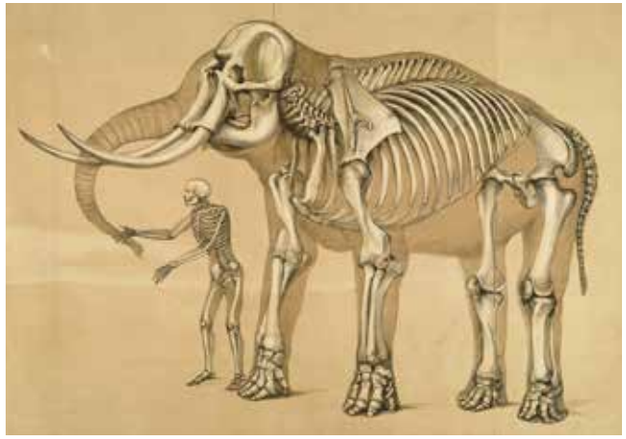
So our shared characteristic of having a (relatively) short neck was what had led me to the elephant.

However, I'd recently had the opportunity to go to South Africa (things were on the up, like I said), and so I'd of course gone on safari hoping to see elephants. And I did. But seeing them in the wild—and up frighteningly close—made me realise that most of the advantages I'd imagined elephants to have, with regards to becoming one, were indeed imagined. The "advantage" of a large build envelope evaporated when I saw just how huge elephants can be. To allow me to really feel what life would be like as an elephant, my exoskeleton would have to be at least the size of a large family car and powerful enough to enable me to push over a tree pretty casually. The only way this was going to happen would be if I added an engine, and then I'd pretty much have built a car with legs. That is a laudable and not unexplored goal, but it just isn't what I was after.

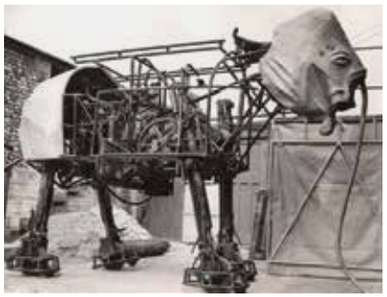
1 Of course, an animal with long legs but a short neck could get around this by kneeling down to eat, but there is a phrase, "sitting duck," and it doesn't just apply to ducks.

2 That is, random mutation, followed by natural selection.

Evolution: totally random![2]



Elephants and us: short necks. From *A comparative view of the human and animal frame* (1860) by Benjamin Waterhouse Hawkins.



Mechanical elephants, surprisingly prevalent.

And while yes, elephants have that all-important short neck, they also have that all-important trunk. The more thought I gave to how I was actually going to make a working trunk, the more impossible the prospect seemed. Massachusetts Institute of Technology made a trunk, but firstly, I'm no Massachusetts Institute of Technology, and secondly, it was pneumatic. This would require dragging around a compressor, which would need an engine, and there you are—back to building a car with legs. Cars are supposed to offer freedom—the open road and all that—but it's freedom only within the system. I was after freedom from the system itself! So dragging a growling (or whining) engine around (and having to worry about filling up with petrol or recharging batteries) wasn't going to feel right. I wanted my animal exoskeleton to be powered by me alone.

Even if the physical problems could be overcome and somehow an exoskeleton could be built that made me *feel* as big and strong as an elephant, I came to realise there was another, deeper problem with elephants: they are, I think, almost too human.

A primary goal of the project was to escape the worry and existential pain of being a human, but I started to feel that psychologically it mightn't necessarily be all that rosy being an elephant, either.

For one thing, it's thought that elephants understand mortality. Just like humans, they'll tend another elephant that's dying. Two elephants have been seen struggling to keep another, who was terminally ill, on its feet; then, when it did lie down to die, they tried to feed it by putting grass in its mouth with their trunks. And when the sick elephant did finally pass away, they stood over its body for days. Families of elephants have been documented visiting the body of a recently deceased matriarch elephant, over the course of several days. It very much seems as if they mourn their dead. And when they do eventually leave fallen kin, they sometimes cover the body with leaves and branches. The behaviour patterns of a family of elephants can take years to return to normal after a violent death in the group, such as at the hands of poachers or as part of a cull, indicatin they suffer from something like posttraumatic stress. Only a handful of species, including dolphins, chimps, and gorillas, have been seen to treat a corpse of one of their kind with reverence. But elephants are the only

other species besides ourselves (and the extinct Neanderthals) who have a documented ritual reaction to the *bones* of their species. Elephants who come across the sun-bleached bones and tusks of an elephant long dead will examine them with their trunks in a markedly different way from how they usually fling around interesting objects (including the bones of nonelephants).

I came to realise that my internal mental idea of elephants was heavily coloured by warm feelings from my childhood toward Dumbo. The reality is elephants are complex, intelligent wild animals, frighteningly powerful and sometimes aggressive. They're perhaps aware of their own mortality, they live in families (and we all know that families are an unending source of stress and worry), and they are prone, it seems, to suffering sadness, depression, and personality disorders just as we are (hold on—actually, that's pretty much all there in *Dumbo*). I'm already an animal prone to these, so trying to escape by becoming an elephant would be akin to jumping from the existential frying pan into another frying pan. So I returned from South Africa with a somewhat disturbed view of elephants and somewhat disturbed by my newfound desire not to become one. So I went to the pub. And, of course, after a couple of pints, a friend made an excellent suggestion: I should seek guidance from an acquaintance of hers who's a shaman who lives in Scandinavia. After all, a shaman is a kind of expert on human-animal relations. And so, when I found myself visiting Denmark to teach a master class, I went via Copenhagen.

* * *

I find the entrance to the Ballonparken. Rows of little wooden cabins, painted iron oxide red with white window frames, sit on either side of a muddy track. It feels like a place from a different time—the past, certainly, but also perhaps a future. There's not much plastic around (a couple of rain barrels) and few of the bright colours of modern life. A lot of wood, both in the buildings and the air; the smell of pine and wood smoke hang in the haze. It's also exceptionally quiet. Really, exactly the sort of environs you'd expect to feature a shaman (but rather convenient for the shops). The last cabin on the left is where I find her.

Annette (the shaman) welcomes me in. It's a cosy place: a single room with a high bed in one corner, a small kitchen in the other, a wood-burning stove, and various bits of dead animal dotted around (a pair of wings "from an eagle," she tells me, a pair of antlers from a deer). I take a seat in a rocking chair next to the stove while Annette makes us some tea. She has long, white hair and black eyes and a face with some deep wrinkles. She puts me slightly in mind of a witch, but a (mostly) good witch. Her cabin really makes me feel like I've stepped one thousand miles north and one hundred years sideways, rather than just off a Copenhagen street.

I'm somewhat encumbered by my technology. I have three digital recording devices aimed at us; their blinking red lights seem quite out of place. Annette requests that I turn them all off, but after some negotiation we compromise on leaving just the one running. When we're settled with tea and crackers, she sits down on the opposite side of the small wooden table and asks me, in her Scandinavian tinged accent, why I've sought her out.

I explain that I'm supposed to be becoming an elephant, but it's not going all that well, and that I was talking to a friend in a pub who had done a [illegible]anic journey with an acquaintance of hers and my friend suggested I try to do one, too, to see if it'll help with my project…

"And, in summary, I was hoping you could send me to the spirit world to meet my power animal?"

She sighs. For reasons of her own, she's not going to help me undertake a shamanic journey to retrieve my power animal. For that I will have to go elsewhere. However, she can clearly see that my trying to become an elephant is, as she puts it bluntly, "idiotic."

Idiotic. That takes the wind out of my sails. "Oh. Why?" I ask.

"Well, what have you got to do with the elephants? Nothing. They're completely alien to the environment you're connected to. If you were a bushman in Africa, then yes, an elephant would be possible. But you are not a bushman, and you're from London. You could only get closer to an animal that's near to you in terms of your shared environment, the places you live in and move through."

"But we have elephants in England—in zoos," I protest.

She dismisses my pedantry: "They are all mad, though."

I have to agree. I tell her I took a vow to never again visit a zoo after taking my girlfriend to Wilhelma zoo in Stuttgart for our second and, as it's turned out, second-worst date. The place was simply bursting with animals driven insane by their captivity, including a pair of elephants, who endlessly performed the same sequence of stereotyped motions.

"So what animals do you have in London *apart* from in zoos? You have Fox. You have Deer."

Deer we have: half of bloody London used to be the stag-hunting grounds of the aristocracy, and a few herds remain in Greenwich Park, formerly hunted by King Henry VIII.

"You are much closer to Deer in terms of the connection through the environment." She sizes me up. "In fact, Deer is still too wild for you. Really…the Sheep."

A pause, during which she considers me more carefully.

"Actually, for you, the Goat."

A goat. Yes…a goat!

A wave of relief and gratitude floods over me. Relief because of narrowly avoiding being proclaimed a sheep. Gratitude because with a goat I *know* Annette has gotten it absolutely right. A goat—a goat is so much more my level. Sure, elephants have conveniently short necks, but what *connection* do I have with them? I mean, just in practical terms it took a once-in-a-lifetime opportunity and a journey across half the world to see them in their natural environment. In contrast, there is a herd of goats just down the flipping road from where I live.

I know. It's a massive cliché: I sought out a shaman about an uncertainty and she told me to stick to my dream. Because, gentle reader, there is a dream mixed up in this project, too, or rather, should I say, a vision, half-remembered from when I was very small.

The vision goes like this: there is a leafy houseplant, which one day I decide to eat. But it's the manner of eating that I particularly remember, because I decide to eat it without using my hands. I remember tugging at a leafy branch with my teeth. The stem resisting, the bush rustling…

I throw my head back determinedly, and the stem snaps off in my mouth and I begin to chew the leaves.

I'm not sure how old I am in this short snippet of internal video, but eating this houseplant without my hands was evidently such a profound feeling, it has stuck with me all these years.

Annette in her wisdom has released me from the elephant that I had arrived at oh, so logically (well, sort of) and without knowing it told me to stick to the dream! Would an elephant tug at a branch with its teeth? No. It would use its armlike trunk. Would an elephant gallop across a landscape? Impossible, because elephants physically cannot gallop! But a goat? Check and check!

Goat.

Annette demonstrating the deer dance in her kitchen.

Annette wastes no time getting down to brass tacks.

"So how could you be a nonhuman being, in this case an animal? Well now, there are old ways, ritual and magic and spiritual ways it's done within shamanic tradition. And one thing is, you get the outer form, the movement, and you start by imitating that. So there are some peoples, like the Pueblo people of the southwest United States, who would have half the skull of the deer, with the antlers. You put them on—"

Annette rises from the table and starts sort of swinging her head with imaginary antlers from side to side.

"—and you feel the weight… And then you have two sticks."

She holds her arms out in front of her, hands grasping the tops of two imaginary deer-leg sticks, and begins rhythmically stepping with them around the kitchen, demonstrating this deer dance and explaining: "So you become four-legged. And there are even hooves on the end of the legs. And so you start this honouring magic, calling Deer in a spirit dance."

She steps over to her mantelpiece and picks up a short stick with black beads tied to one end—a rattle. She starts rattling as she continues moving around the kitchen.

"This is also a way of doing it…of becoming one with the spirit of an animal. A rattle with this sort of lightness of sound…The lightness of a beautiful animal."

She continues to dance around the kitchen, rhythmically shaking her rattle, and starts to hum deeply but then abruptly breaks out of it, returning to sit at the table and handing me the rattle to inspect.

"These rattles are used all over the world. I have much bigger rattles, from the stag and the reindeer, which make a deeper sound, but these are the hooves of a row deer." She's referring to the beads tied to the end of the rattle.

"Every one of these is like a fingernail, and there was a bone I had to pull out. Like the tip of the finger."

"Gruesome."

"Well, it was my Christmas Eve project."

Annette continues: "So in a way, it starts through cold imitation. But then you can enter into this 'between-the-worlds state,' or 'trans-ecstasy,'

The earliest known drawing of a Siberian shaman, from the 1692 book Noord- en Oost Tartarije an account by the Dutch explorer Nicolas Witsen of his travels in Siberia. It portrays an Evenk shaman, performing a ritual with a drum, and is labeled "Shaman or Devil-Priest.

Hunters' or Deer Dance, painted circa 1932 by Alphonso Roybal.

San Juan Pueblo deer dance, photographed circa 1977 by Richard Erdoes.

or 'changed state of consciousness.'" She waves the words aside to imply the term itself is unimportant. "But because you have called and honoured the spirit of Deer, you can then *experience* this transformation, seeing the world through the eyes of the animal."

She leans back in her chair, concluding: "So, that sort of changed state of consciousness is *pretty* helpful."

"Right, yes." I'm nodding and agreeing, but I'm wondering how I'm going to enter into a state of trans-ecstasy without visiting one of London's more insalubrious nightclubs. She continues: "However. These people *know* the animal. They have been following and watching and remembering the life and the way of it their whole lives. *It's in their bones.* So I don't know how much it will work if you have *no* knowledge of the animal."

I'm a little offended by her emphasis on the word *no*, because surely I have *some* knowledge of "the animal." But when I come to think of it, I do see many more dead (bits of) animal than living ones in any given week. A walk through the supermarket and there are lots of bits of dead animal from a variety of species, whereas a walk through the park? Well, some pigeons and a few dogs. I did a quick survey. Number of animal species represented in my local supermarket: twenty-nine. Number of animal species I see in a trip to my local park: two. Including *homo sapiens*.

So Annette's summing up my knowledge of animals—me being someone who has lived in cities my entire life—as essentially nil in comparison with people who have grown up tracking and hunting them is perhaps fair (though I'm not that happy about this newly realised lack of nonhuman animal contact; I resolve to get a cat). In fact, that's what Annette does professionally sometimes—she tries to "reconnect city people to their hunter-gatherer souls." And, she tells me, "they take to it like ducks to water."

Our conversation continues, and Annette digs out a photograph of a shaman from Siberia doing an antelope dance (my notion that shamanism is a "Native American thing" has been corrected; the word originally comes from Siberia and is now used to describe similar practices found in cultures indigenous to every part of the globe). I comment on the fact

that the photograph's date is almost a hundred years old. Annette fixes me with a look.

"People have been trying to bridge the gap between animal and human always. *Always*."

And it seems she's quite right.

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In 1939 a German geologist named Otto Völzing was helping with the excavation of the Hohlenstein-Stadel cave in the Swabian Alps in southern Germany. The excavations had been successful, and Völzing had dug up the skeletons of thirty-eight Stone Age people as well as the skulls of a man, woman, and child. For some long-lost reason, their heads had been severed and buried at the entrance of the cave, all arranged staring toward the southwest. The dig, funded by the Nazi SS to find evidence for their belief that human civilisation started in Germany, was cut short by the start of the Second World War. Völzing was called up to fight, but on his last day he found a whole bunch of fragments of ivory buried deep in the very back of the cave. These he diligently packed up in a box before going off to fight the Allies.

The box of tusk shards ended up in a local museum and was forgotten. It wasn't until 1969 that someone doing an inventory realised that the shards were woolly mammoth tusk and actually the remains of a statuette. The figure that emerged as the fragments were pieced together was a carving of a human figure with a lion's head, and the latest dating techniques show it was carved forty thousand years ago. This makes it the oldest non-abstract art and the oldest figurative sculpture in existence, and it's a human-animal hybrid.

While we can't know why it was carved, it's clear it took a lot of work; a sculptor recently tried to make an (elephant) ivory copy using only the type of flint tools that were around forty thousand years ago, and it took him almost three months of solid work. This effort means it must have been important to the makers. So while it could have been a toy or something (the Lion Human does seem smiley to me), by far its most likely purpose was as some kind of spiritual talisman.

Löwenmensch ("the Lion Human") of Hohlenstein-Stadel, carved 40,000 years ago and the oldest work of figurative art yet found.

Representations of human-animal hybrids have been found painted in the deepest parts of other caves frequented by people living during the Upper Palaeolithic (the end of the Stone Age). For example, there are the paintings in the Chauvet Cave in the Ardèche Gorge in France. This cave, stumbled into by three spelunkers in the early 1990s, had until that moment been sealed off for 25,000 years. It contains hundreds of paintings of animals, but in the deepest chamber there's a figure of a half-human, half-bison that was painted by a person 30,000 years ago. Also, in a cave in Lascaux, France, there's a painting of a man (he has an erection) with a bird's head, lying on the floor, which is 16,500 years old. And there's the so-called Sorcerer painting from around 13,000 years ago in the Trois Frères Cave in Ariège, France, showing a man with antlers, dancing.

The bison-headed human painted 30,000 years ago on a rock pendant deep in the Chauvet Cave.

Bird-headed man with a bird-headed staff, lying (dying?) in front of a bison that seems to have been disembowelled by a spear.

The art at Trois Frères Cave is difficult to make out in photographs, as it's engraved into the rock as well as drawn with charcoal. The discoverer of the cave made sketches of the cave art, though. Top: The Sorcerer figure with antlers and tail. Below: A bison-headed man playing a nose flute.

All these examples are from a small patch of Europe. It was once thought that the Stone Age Europeans invented the practice of sculpting and painting figures (with the implication that the cognitive and cultural beginnings of creativity were in Le Europe, reinforcing the nineteenth-century idea that Europeans and their descendants are exceptional). But this Eurocentric view seems to have been more due to the fact that the conditions in Europe have been right for preservation and, more important, study: only in 2014 did a scientist do the work to accurately test the age of some cave paintings of animals in Indonesia. She found them to be 35 to 39,000 years old, the same age as the oldest paintings in Europe. The temporal concurrence yet wide geographic separation of these similar Indonesian and European paintings suggests that the practice likely started before the populations who spread east toward Indonesia and west into Europe diverged from North Africa around 60,000 years ago.

Who knows when a person actually first imagined being a lion-man or a bison-man or a bird-man (or, for that matter, a goat-man)? But as the cave paintings and figurines are thought to represent the beliefs people had about the world before history—our first attempts at answering the eternal questions Who am I? Why am I here? and Where do I go?—it's likely people have been trying to bridge the gap between humans and other animals for a bloody long time, if not, as Annette said, *always*. So really, to want to become a goat is pretty standard. In fact, historically speaking, it's almost odder to *not* want to become a goat.

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I ask Annette why a shaman would want to transform into an animal, anyway.

She tells me that shamanism originates from when we were all hunters and gatherers, surviving on whatever we could find or kill. A shaman would try to become one with an animal in order to track and hunt it.

But it's also an animist worldview. In this system it's not just humans who can have a soul or who are considered persons; animals are very much people, too. This presents a bit of a conundrum for the shamanic hunter

because if you're hunting and killing and eating an animal and an animal is a person, well, you're engaging in murder and cannibalism. So another reason a shaman would want to become an animal is to ask forgiveness from the animal spirit for killing it. This seems a little bit paradoxical from my point of view.

"So part of this becoming an animal is to sort of lessen your guilt?" I ask Annette, seeking clarification.

"Well, it's like you recognise they are your kin. They are your relatives, and we have an ongoing agreement. Hunting is a pact. And in order for Deer to allow itself to be met and killed, you have to pay your honours by right behaviour, and part of this is to become the prey. But you have to fulfil your part. Humans aren't doing that."

She tells me about a people, the Yukaghirs, who to this day are practicing shamans and hunters in Siberia: "These hunters try and take the humanness off themselves and become one with the animal, so they can think like the animal and track it."

She refers me to a book, *Soul Hunters*, by the anthropologist Rane Willerslev, who (partly to escape being murdered by the Siberian authorities) lived and hunted with a group of Yukaghirs for eighteen months deep in the forests of Siberia. In his book Willerslev describes a hunter called Old Spiridon, who hunted elk dressed in elk fur, with elk ears on his hat and the skin from the legs of an elk covering his skis, so he'd sound like an elk moving through the snow. Willerslev was with Old Spiridon as he closed in on an elk and her calf and watched as he began moving and acting like his prey to such an extent that the "female elk…captured by his mimetic performance, suspended her disbelief and started walking straight toward him." Then Old Spiridon shot it and its calf dead. This is all very logical and easy to comprehend: "becoming" an elk clearly helps with killing elks, just as calling like a duck helps with killing ducks. What's less easy is Old Spiridon's description of the encounter. He said that he was seeing the elk as "a beautiful young woman, beckoning to me….If I'd gone with them, I would have died myself, at which point I shot them both." Not only did Old Spiridon become an elk, the elk at the same time became a human. For Annette and the Yukaghirs and the other shamanic

peoples of the world, the divisions between human and nonhuman are much more flexible than I'm used to.

When faced with a story like Old Spiridon's, the Western–born and bred like me will say that he's making it up for effect, and if he's not making it up, then he must just be delusional. Or, if we're adopting a more modern, respectful-of-different-cultures approach, we'll say, "Ahhhh, the wise one must be speaking in metaphor: he means it's *as if* the elk became a woman or the shaman became *like* a goat. And when the lying/delusional/wise primitive insists that no, he's not speaking in metaphor and that the elk *was* a woman and, yes, the shaman *became* a goat, we smile and nod and say, "Yes, of course, wise one," and then, sotto voce, "They haven't quite got the concept of metaphor yet, though, huh?"

Now, I'm rather scientifically inclined and not one to elevate ancient belief systems as necessarily more in tune with the natural world. For instance, when the ancient Aborigines reached Australia, they hunted 60 percent of the large mammals to extinction.[3] However, I'm also trying to become a goat, and, furthermore, Annette, a shamanic practitioner, is kind and smart and doesn't seem delusional or primitive or intellectually unsophisticated. She does have a very different view from mine of what animals and people *are,* though.

Willerslev asks, what if we just consider the possibility that these shamanic people mean what they say when they say they can become animals and animals can become people? I think he's on to something. I mean, two groups of people looking at exactly the same situation and coming to wildly different conclusions, both of which are correct depending on underlying assumptions held about the world—that's never happened before, right? Willerslev goes on to trace the difference of opinion as to the transmutability of humans and animals back to different underlying philosophies as to what constitutes being a person.

Now, gentle reader, I'm not a professional philosopher, so if you are, I suggest you just close your eyes for the next few paragraphs because I

3 And overhunting by Yukaghirs has led to the decline of the elk populations in their area. Not that there's many buffalo left in the USA, or bears in the UK, for that matter.

think I'm about to wade in and bludgeon in most gruesome fashion a discourse that has been continuing for hundreds of years across thousands of pages of philosophical treatise. And with that caveat...

Willerslev in his book argues that for Western-educated minds like mine, the underlying assumptions I hold about my self and other selves are still profoundly influenced by the philosophy of René Descartes, and his famous thought experiment described in his book *Meditations on First Philosophy,* published way back in 1641.

The story goes that Descartes, sitting by the fire one night, asked himself: What can I know for sure? All of the reality I think I experience could be an illusion perpetrated by a malignant demon. Or, to bring it up to date: We could all just be in a big computer simulation, dude. Although it *seems* that I'm sitting in a chair by a fire, how do I know it exists? I could be dreaming, or I could just be a weird disembodied mind somewhere, somehow being fed the illusion that I've got a body, and that there's a chair it's sitting in. I can doubt everything; how do I know I even exist? From this methodical doubting of existence, Descartes tries to establish a solid foundation for some certainty. He reasons that there's one thing at least he can be certain of, and that is that there's something doing all this doubting. All of physical reality could be an illusion, but in order to have that doubtful thought, some thinking must be happening, and therefore the "I" that's doing the thinking has got to exist: *Cogito ergo sum.* I think; therefore I am.

Having established this one certainty in an otherwise doubtful world, he goes on to argue that one's mind, the I, *must* be a different thing from one's body. This is because two things need to have the same essential properties to be the same. Descartes argues that while it's easy to conceive of dividing a physical thing like a body or a pencil in to parts, he can't "distinguish any parts" within his mind; the mind is "something quite single and complete." Therefore, the body is essentially divisible, and the mind is essentially indivisible, and because one thing can't have both these contradictory properties, the mind and the body must be separate.

So Descartes managed to elevate reason as the fundamental characteristic required for something to have a self, and to separate the reasoning

mind from the physical body. Conveniently, if you're a Christian, as Descartes was, the argument that the mind and body are different plays nicely with the notion that a person has an eternal soul that, after the death of the body, can separate and go to heaven. Furthermore, Descartes argues that because animals can't reason (they couldn't think, *I* think therefore *I* am), they can't be conscious. So they're effectively just biological automata, and any of their cries of pain or what have you can be ignored as being purely mechanical, like the chimes of a clock (Descartes was a pioneer of vivisection).

His classic bit of reasoning has become known as Cartesian dualism, and dualism in various forms has had a pretty big effect on Western science and philosophy—mind versus body, reason versus instinct, civilisation versus savagery, humanity versus animality, objectivity versus subjectivity—and these dichotomies have been causing no end of problems ever since. But for our present purpose the important implications are that animals don't have consciousness, and more fundamentally, our own consciousness is independent of the physical world.

But now we turn to the philosopher Martin Heidegger. Join me as I swim so far out of intellectual depth I'll be at risk of drowning.

The phenomenological alternative to Cartesian dualism, elaborated in the 1960s by Heidegger among others, turns Descartes on his head. For one, Heidegger points out that it's actually not possible to think without thinking *about* something: Descartes's "I think therefore I am" should actually be "I think *about something;* therefore I am." While one of the things we can think and reason about is our own minds, we can think about plenty of other things too. And that opens a crack: What makes thinking about your own thoughts more fundamental than thinking thoughts that make up other aspects of your perceived existence? Heidegger basically rejects the idea that the fundamental aspect of your being, your I, is a mind that can reason.

Sure, when we're pontificating about ourselves, we might reason that our mind could be disembodied or that it looks out from just behind our eyes (at the pineal gland in the centre of the brain is where Descartes imagined it), making decisions and telling our body to do things. But this

rational consideration is just one mode of thinking, which for the most part doesn't reflect what it's like to exist anyway. After all we can only work from the evidence available, and I don't know about you, but my moment-to-moment existence is bumbling along as things momentarily capture my attention: oh, a little itch on my nose; uncross and recross my legs; oh, look, a lady; back to work; this chair *is* uncomfortable; scratch my nose; hold on, this is freaking me out; I've got to remember to breathe! Oh wait, phew, breathing happens automatically. It's funny, that, when you think about it.

Voilà, bumbling along—a mixed bag of sensations that when it's feeling philosophical *can* reason abstractly like Descartes, but at a more fundamental level is inescapably and inseparably, as Heidegger calls us, a "being-in-the-world."

So how does this relate to people becoming goats and goats becoming people? Well, according to the phenomenological view, our selves exist as a result of our interactions with the world. Willerslev argues that the Yukaghirs, rather than having a Cartesian view of a person as a self-contained mind that isn't fundamentally dependent on the external physical world, the Yukaghirs take a more phenomenological view. Rather than viewing their selves being independent discrete minds, they think of themselves as so dependent on their physical context that what they are is constructed by where they are and what they're doing. This also helps explain the importance of setting for shamanic rituals. So when shamans change their behaviour and physicality by mimicking an animal, they are changing their context; and since what you are depends on your context, if you change your context radically enough you can actually move toward becoming that animal. Willerslev writes that the Yukaghirs are actually careful not to go *too* far in changing their body and behaviour because of the danger of fully becoming that animal, from which apparently there is no return.

It's quite difficult for me to imagine myself really believing I've become a goat, or rather (my mistake) *actually* becoming a goat by changing how I behave and how I move. It's just not how I've been brought up. But if Old Spiridon, through his behaviour, managed to change his

relationship to the world so much that the female elk didn't see him as a dangerous human hunter anymore, and he saw the elk as a human in turn, well for a moment, the elk and the person were also the person and the elk. As the Yukaghirs point out to Willerslev, from the elk's point of view, *it's* the person.

This is the profound shift in perspective I need to try to achieve with my project. If I'm to experience the world as a goat, I need to change my context in the world to the extent that somehow I look at a chair and don't automatically associate it with sitting. That I look at a word and don't automatically read it. That I look at a(nother) goat and think of it as another person, like me.

* * *

Before I leave Annette's cabin to go and teach my master class, she has a final word on my project. She advises me to try to go further into "this mystical, spiritual process of honouring the animal and calling for its spirit." She's sure, however, that in the end I'll have "to peel off the mysticality of it," because, she thinks, what I've set out to do, trying to use technology to get closer to nature, is a paradox: "No one would get such a crazy idea like this fifty years ago. This estrangement from nature has gone to completely idiotic extremes already, and it continues down the abyss."

"Our technology is changing us. That's without doubt," I say.

"You have to decide if your project is really about trying to make a costume, or is the most important thing trying to find a way for people to feel their kinship, to bridge the gap, to feel like an animal. Because then you're gonna do everything much simpler. Then it's the mystical thing. Then it's an education."

* * *

Back in London a couple of weeks later (everyone said the master class was probably one of the greatest examples of pedagogy in the history of design, by the way), I decide to go a little further into the spiritual aspect of shamanism and sign up myself and, after some persuasion, my friend Simon for a Saturday workshop in Newport, Wales, called

"An Introduction to Shamanic Journeying." Simon is an old friend, and though he's not keen on Wales as a place to visit (childhood trauma), he does appreciate the odd foray into unreality, and we've been helping each other with our various more or less absurd projects since we were teenagers. On the way there we both decide to approach the day with an open mind (and I make Simon swear that he'll not mercilessly ridicule anyone). We've been asked to bring a cushion, a blindfold, and a blanket so that we'll be comfortable when we're journeying, which makes me think we could be "away" for some time. I'm very much hoping that my animal helper spirit will be Goat (and if not Goat, then maybe something cool like Eagle or Cheetarah).

The Newport Clinic of Holistic Health is a terraced red-brick house just off the M4 motorway, and the workshop is to be held in the meeting room. Our fellow shamanic initiates are six ladies ranging in age from nose-studded student to late-middle-aged mother of grown-up children. I get the impression that a couple of group members are here to try and deal with personal tragedy, as I overhear them talking to Maxine, our group leader, showing her objects they've been given special dispensation to bring along to help with contacting specific spirits in the land of the dead.

The chairs are cleared to one side, and once we're all sat on our cushions in a circle, Maxine takes us through the basics of shamanic journeying on the whiteboard, helping us choose our personal *axis mundi* and so on. Your *axis mundi* is a place that you know well, that becomes your gateway from ordinary reality in to nonordinary reality. The place you go to in your mind to climb up to the upper world or dig down to the lower world. A tree from one's childhood garden is a "very good one, Thomas." The day wears on, with Maxine telling us at some length her own personal story of how she was chosen to become a shamanic practitioner, until finally, in the late afternoon, we get to try journeying ourselves. We lie back on our cushions, I shut my eyes, and Maxine starts banging her drum, a fast intense rhythm, and I imagine my *axis mundi* and dig down into the roots, and down and down and down and, well, it sort of works…

The Toaster Project

Deconstruction

Deconstruction

Reverse engineering is the process of deducing how something works by taking it apart. Using the potentially misguided rationale that the cheaper the toaster the fewer parts it will contain, and thus the simpler it will be to reproduce, I dismantle the cheapest toaster I can find: the Argos Value Range 2-Slice White Toaster.

So, let's see what you get for your £3.94†…

I dissect my patient into 157 separate parts, but these parts are made up of sub-parts, which are themselves made up of sub-sub-parts. Does the variable resistor that controls the toasting time count as a single part? But it's made of eight sub-parts, so perhaps it should count as eight? Does a capacitor count as one part or eight? I peel open its thin outer plastic covering, open the inner metal casing, and rolled up inside are

† Price correct at time of writing. There must've been some kind of major upheaval in the value toaster manufacturing business, because since then the price has rocketed to £4.47 ($6.95).

What's inside . . . a capacitor?

two very thin strips of metal with a metal pin clamped to each, with a strip of weirdly damp paper (soaked in some chemical perhaps?), and a rubbery bung through which the pins poke to be soldered onto the circuit board. And what about the live, neutral, and ground wires of the power cord, coated with colourful plastic and all contained within a white plastic outer sheath? What about the forty-two individual strands of copper, woven together to make up each of the live, neutral, and ground wires in the power cord? If I were to dissect all the components all the way down to their discrete "bits," then I've calculated my toaster-part count would be 404 individual bits.

Things get even more difficult when you start trying to divide the bits according to their material. First, without some serious chemical analysis, it can be impossible to tell if two plastic parts are the same plastic, or in fact different plastics that just look the same. Ditto for the metals.

On top of that practical constraint is the more metaphysical question of what is "the same"? Presumably the brown, blue, and green and yellow striped insulating sheaths of the wires are the same plastic, but they must have different pigments added to colour them. Does this then make them strictly different materials?

The metals, which I thought would be fairly easy to identify, also pose problems. I can pick out the copper OK (though even then some bits of copper appear more "copper" coloured than others), and the bits that are brass coloured are presumably made of brass.

Except that the brass-coloured screws are magnetic, whereas the brass-coloured pins of the plug are not. Steel I know is definitely magnetic. But while some of the silvery metal parts are magnetic and so could be steel, many are not. Depending on where in the toaster they're found, two very similar-looking metals can have different properties, or parts that you'd expect to be made from the same material (like the two springs) are clearly not (they're different colours, for a start).

The materials used in the electronic components are a whole other story. What's the metal inside a transistor? What's that white stuff inside the resistor? The six-coloured bands meticulously painted on every single resistor to show how much they resist the flow of electrons: what are the paints made of? Where do the pigments come from?

If I lump stuff together that roughly looks like steel, that looks like brass, that looks like copper, and so forth, without worrying too much about "slight" differences in colour or consistency, and put plastics together that feel the same, and don't get too lost in all the different exotic materials in the electronics, then I estimate that my toaster is made of at least thirty-eight different materials. Seventeen of these are metal, eighteen are plastic, two are minerals (the mica sheet and talcum powder stuff inside the power cord), and one is just weird (strange wet papery rubber inside the capacitor).

If I got some kind of chemical analyst involved, then the materials count could easily rise to over a hundred.

Bugger.

I'd expected a toaster to be perhaps a little complex, but really, four-hundred-plus parts? One-hundred-plus different materials from God knows where? How could something with this much in it cost £3.94, the price of a hunk of cheese, and not fancy cheese either.

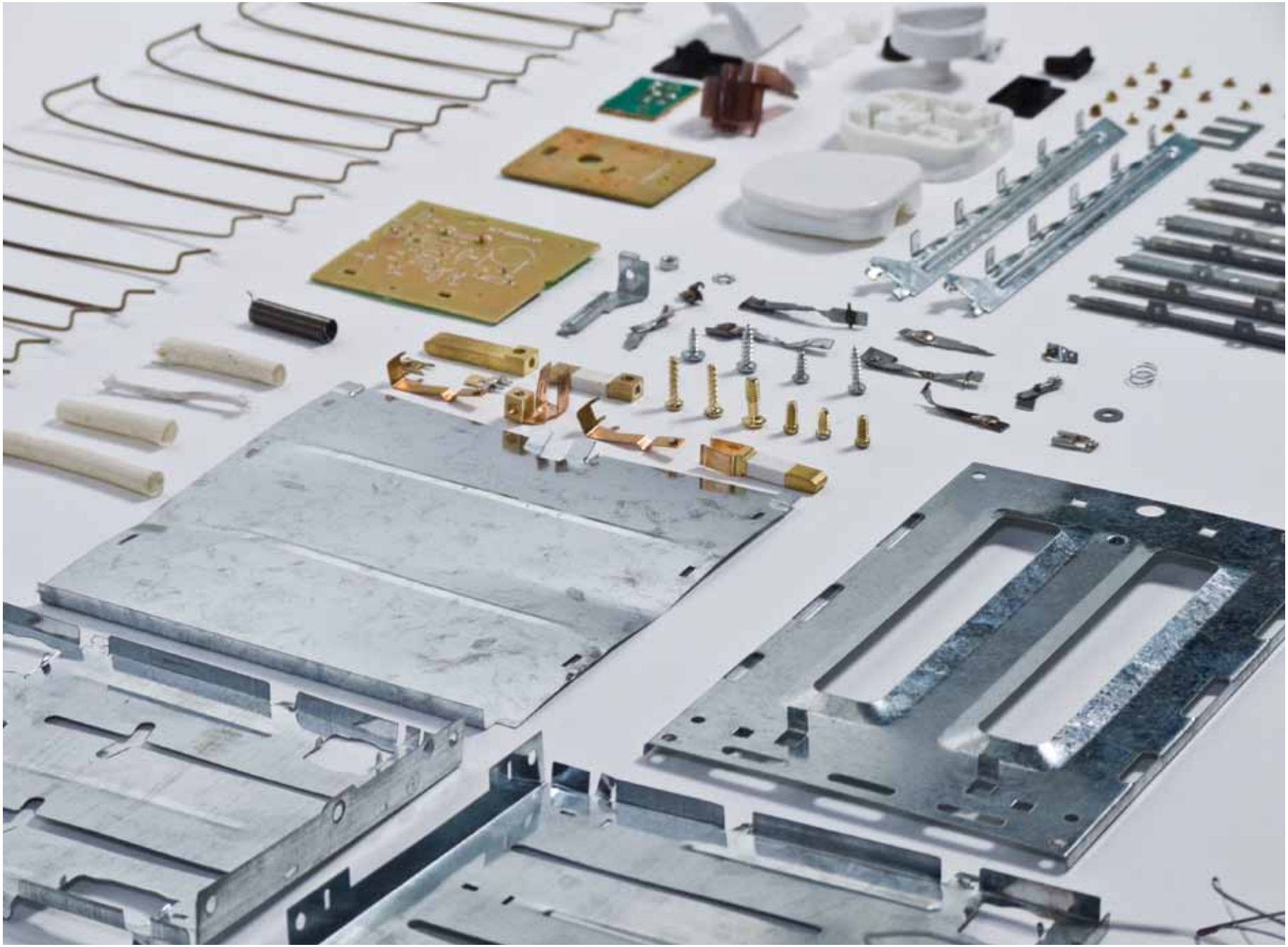
My life's work stretches out in front of me… It wouldn't be so bad, travelling the earth on a quest to extract the hundred materials I need to create my vision, searching for semiconductors amongst icy glaciers, exotic forests, and forgotten lakes. I could grow a beard. After a few years I might tell my story to a fellow traveller and become something of a legend. Eventually someone might start a Facebook group about me, "Fans of the mad bearded Englishman wandering around India trying to make a toaster."

Hmm.

Alternatively, I could make a few minor material substitutions.

To start with, the element: the hot passion within every toaster. No element = no heat = no toast. After some research I discover that for most toasters, the element is made of nickel-chromium resistance wire, sold under the brand name Nichrome. Nichrome is used because it has a high electrical resistance, so it gets hot when an electric current is passed through it, but it's also got a high melting point, so it doesn't melt when it gets hot.

Unfortunately, after a little more research I find that to extract chromium from its ore, one produces a by-product called hexavalent chromium. If you've not



Steel

Mica

Plastic

Copper

Nickel

seen the film *Erin Brockovich*, next time it happens to be on TV, have a look. It's based on a true story, and it's got Julia Roberts in it. She plays the peppy legal clerk who takes on the giant Pacific Gas and Electric Company, acting on behalf of some people suffering from a debilitating sickness caused by the hexavalent chromium used in the PG&E plant. If Julia Roberts says the stuff is bad, I think I should avoid it if I can.

Fortunately for my health, heating elements can also be made from Constantan, an alloy of copper and nickel consisting of about 55 percent copper and 45 percent nickel. I can replace the dangerous chromium with copper, which I need for the wires anyway, and kill two birds with one stone.

Brass, which I'd need for the plug pins, is just copper with a touch of zinc. Zinc sounds rather exotic. I don't see much advantage to it, to be honest. I'll lose the zinc and just use plain old copper. And so on…
I pare down my materials to the bare minimum from which I think I can make a toaster that retains the essence of "toasterness." These are: steel, mica, plastic, copper, and nickel.

I'll travel to a mine where iron ore is found, collect some ore, somehow extract the iron myself, and then somehow change it into steel. The same for the mica, copper, and nickel. I'll need to get hold of some crude oil from which to refine the molecules for the plastic case.

I'm going to need some advice…

* * *

From: Thomas Thwaites <thomas@thomasthwaites.com>
To: j.j.cilliers@imperial.ac.uk
Date: 7 November 2008 02:08
Subject: **The Toaster Project?**

Dear Professor Cilliers,

I'm a 2nd year postgraduate design student at the Royal College of Art (just across the Royal Albert Hall from your office at Imperial College). Sorry for contacting you just "out of the blue," but I'm trying to build an electric toaster from raw materials and I'm in need of some advice.

As a first step I think I need to get an idea of whether the project is hopelessly ambitious, or just ambitious. I was wondering if I could perhaps come to the Royal School of Mines and briefly discuss the shape of the project?

Yours Sincerely,
Thomas

From: Cilliers, Jan J I R <j.j.cilliers@imperial.ac.uk>
To: thomas@thomasthwaites.com
Date: 7 November 2008 07:16
Subject: **Re: The Toaster Project?**

Thomas,

This is utterly fabulous! Come see me whenever you can, I would be happy to help in whatever way I can.
Call me on 07 ———— first, or email.

Jan

The Royal School of Mines, Imperial College of Science and Technology, London

Professor Jan Cilliers, Chair in Mineral Processing and director of the Rio Tinto Centre for Advanced Mineral Recovery

The Royal School of Mines, Imperial College, London
Senior Common Room
Friday, 7 November 2008 (Lunchtime)

Professor Jan Cilliers holds the Chair in Mineral Processing at the Royal School of Mines at Imperial College and is the director of the Rio Tinto Centre for Advanced Mineral Recovery. He's also a jolly nice chap; he bought me fish and chips at the Imperial College Senior Common Room. The following is a transcript of our conversation. For succinctness I've removed about a half hours' worth of me saying "err," "um," "well," and "you see."

PROFESSOR CILLIERS: So, this toaster thing. In toaster terms I have lived through several generations of toasters. The first toaster we had in my house had little doors that opened up — and when you opened the door the bread turned itself. Do you remember those?

ME: Um, not really, no.

The reason I ask is that one of these toasters would be much simpler to do than a modern toaster. I assume it's not going to pop up, right?

I would quite like to try and make it pop up.

Bloody hell.

I was even thinking, well at some point somebody made the first transistor or resistor or capacitor or something, so it must be possible to make these things yourself.

You're going to plug it in and you want it to work? So are you going to make the cable or...?

[I nod my head.]

Really. Right, well. How much time have you got?

Until the degree show next summer.

I see. So, why a toaster?

Well, I guess because they break all the time. [This was not a brilliant answer. I knew it, and Professor Cilliers clearly expected more of an answer to a question quite fundamental to the project. At a loss, I played the artist card...] And well, you know, a toaster just feels right.

[Oh dear. A toaster "feels" right.]

* * *

SO, WHY A TOASTER?

What I didn't say to Professor Cilliers at the time but have since discovered is something along the lines of the following. The reason that I want to create a toaster, specifically an electric toaster, is because the electric toaster, like no other object, seems to me to encapsulate something of the essence of the modern age. To understand how they achieved this status, we'll have to look back at how they came to be such a mainstay of kitchen life for the peoples of the world who toast.

Toast: A Brief History

The first toaster, of course, is a bit of a grey area—probably being nothing more than a stick with a piece of bread on the end of it held over a fire. In ancient Rome toasting was a popular way of preserving bread; *tostum* is Latin for burning. Fact.

Toasting really took off, however, with the invention of the electric toaster at the beginning of the 1900s. The years before had seen electricity begin to change people's way of life. The Edison General Electric Company established the first central power station in New York in 1882 to power the eight hundred electric bulbs of its subscribers. The same year the first power station in London (near Holborn viaduct) was switched on, providing electricity for some electric streetlights and a few nearby private houses. Twenty years later, and electricity suppliers faced a problem: there were pronounced peaks and valleys in the demand for their electricity. Electrical consumption rose slightly in the early morning, fell to almost nothing during the day, and then peaked again as it got dark in the evening.

However, to meet morning and evening demand, suppliers had to continue generating at peak level output throughout the day. Big power stations can't be adjusted up or down from hour to hour, and storing the quantities of energy they generate wasn't (and generally still isn't) practical or economical. Thus, a way to increase demand outside of peak hours was needed, and electrical appliances proved successful at doing just that. If you can't, or don't wish to, cut back production, then try to manufacture demand—the story of the twentieth century?

In the early 1900s, AEG (now known as the household appliances manufacturer AEG-Electrolux) was primarily a *generator* of electricity. In 1907 Peter Behrens, perhaps the first industrial designer, was hired as a consultant to find ways to increase demand for electricity during the day. His solution? The first electric kettle, developed for AEG and produced in 1909. That year is also considered by those in the know to be when the first commercially successful electric toaster was launched by the Edison General Electric Company,

Peter Behrens (1868–1940), electric kettle, nickel-plated brass and rattan, 1909

The Edison General Electric Company model D-12 toaster

the model D-12. When this toaster hit the shelves, I imagine it would've been regarded as a rarefied luxury, purchased by those early adopters at the forefront of the technological wave. Something like the iPhone is now—though making this comparison will quickly age this book. By the time you read this, the iPhone will of course have been superseded by the super-iPhone or somesuch, just as early toasters were superseded by the dual-side toasting, self-timing pop-up toasters, which in turn will also likely be superseded by as yet undreamt of toasting sophistication (unless, to use Doors front man Jim Morrison's memorable phrase, "the whole shithouse goes up in flames," or people just stop liking toast).

Anyway, at the time of the first toaster's development, the additional convenience it provided would've been a boon. Toast without stoking the coal-fired range? How terribly marvellous! One doesn't even require one's butler! A hundred years on, however, and the electric toaster is mundane and common throughout much of the world. Amongst the jumble of products and services we are now surrounded by, the humble toaster's function seems inconsequential.

Toaster production, however, is no longer inconsequential. The industry that produces them (and all of our other stuff), has grown such that the ability of the natural environment to accommodate it is being strained in a whole variety of ways. Even on a planet-sized scale, its effects are no longer trivial. The contrast in scale between this globe-spanning industry and many of the inconsequential products we use it to make seems a bit absurd—all of this, for toasters?

Are toasters ridiculous? Close up, a desire (for toast) and the fulfilment of that desire are totally reasonable. Perhaps the majority of human endeavour can be reduced to the pursuit of additional modicums of comfort—like being slightly less tired, being slightly less bored, or just an evenly crispy piece of toast—small trifles, to which we quickly become accustomed. This millennia-long striving to better our lot has thus far enabled more people than ever to buy a toaster (amongst other notable achievements). I really appreciate being comfortable and living when and where I do, and I'm also generally quite a fan of technology. But it feels like some things make such a marginal contribution to our lives that we could do without them and not even notice. This begs the question of what goes and what stays, and I can already imagine the arguments over whether hair straighteners are more or less essential than electric shavers. So far we've settled things by simply voting with our wallets, and it seems the clear winner at the ballot box is more rather than less. But what if some of the things we're voting for aren't being entirely candid about their origins? What if much of the cost of making them is hidden from us, or falls unequally on someone else? What if the vote is distorted?

The toaster serves as a symbol, my figurehead for the stuff that we use but is maybe unnecessary, but then again is quite nice to have, but we wouldn't really miss, but is so relatively cheap and easy to get that we might as well have one and throw it away when it breaks or gets dirty or looks old.

So that is "why a toaster."

Well that, and because I really like Douglas Adams: "Left to his own devices he couldn't build a toaster. He could just about make a sandwich and that was it."

This quote is taken from *Mostly Harmless*: *The Fifth Book in the Increasingly Inaccurately Named Hitchhiker's Guide to the Galaxy Trilogy*.

Our hero, Arthur Dent, a typical man from twentieth-century Earth, is stranded on a planet populated by a technologically primitive people. Arthur expects he'll be able to transform their society with his knowledge of science and modern technology, like digital watches, internal combustion engines, and electric toasters, and thus be acknowledged as a genius and worshipped as an emperor. However, he realises, that without the rest of human society he can't actually make any of it himself. Except, of course, a sandwich, one of which he happens to make himself one afternoon. This never-before-seen advance in eating technology so stuns the villagers that they promptly elevate Arthur to the high office of Sandwich Maker, whose sacred duty it is to hone and research the advanced art of the sandwich.

I read this book when I was about fourteen. The passage must've had a great effect on me to linger in the synapses of my brain only to resurface a decade later as the inspiration for my second-year master's project.

My god. What would I do if I crashed on a strange planet? How would I even make a knife? What Adams draws on—a remarkable lack of knowledge about the basic technologies that underpin our modern existence—is true for most of us today. The idea that modern society divorces people from practical ability is not new, and usually carries negative connotations. Imagine a sci-fi film on the topic: *Toast*. Plot: The dust settles and surviving United Kingdom residents realise that although well versed in the health and safety implications of improper typing ergonomics, they don't actually know how to make anything. How would people toast bread in this post–apocalyptic world?

Is it possible I could avert this disaster by reverse engineering a toaster, examining its constituent parts and materials, and recording my attempt to construct a duplicate from raw materials, using only the tools that might be available in post-crash civilisation?

And that is another reason why I want to build a toaster.

* * *

The Royal School of Mines, Imperial College, London
Senior Common Room
Friday, 7 November 2008 (Lunchtime)

My meeting with Professor Cilliers continues . . .

PROFESSOR CILLIERS: OK. So can you have some people doing stuff for you, or do you insist on doing it all yourself?

ME: Well, I want to make it myself...

And how set are you on the materials being comparable to modern materials?

[Silence... I'm quite set on it.]

Right. Well, if you use metals that are different they'll be more expensive but much easier to produce. So iron and steel, everyone uses iron and steel for everything because they're cheap, they're produced in such vast quantities. For you to make iron and steel it's going to be, err, a real bitch. But if you were to use copper, well that could be quite feasible because you don't need high temperatures. That's why we went through the Bronze Age first, because it's piss easy to do.

Right.

Well the other thing is... you can say, well, can I use electricity? Do I have to make that myself? Can I use acid, do I have to make that myself? Just how far are you going to the root of the problem?

Well, I've got these rules...

THE RULES

The rules of the project are all-important. Of course I could make a toaster by going down to the Maplin Electronics shop, buying some Nichrome wire to bend into an element, buying an electric cord and a plug and wiring the whole lot together. Or I could make a toaster by sticking a piece of bread on the end of a stick and holding it over a fire. But that would be cheating…

Rule 1.
My toaster must be like the ones they sell in the shops.
What is a toaster? An object that toasts bread. A fire toasts bread. A fire is not a toaster. Why is a fire not a toaster? A fire is not a toaster because when you ask in a shop for a toaster, they don't sell you a fire. Thus,

A. It must be an electric toaster that plugs into the mains electricity supply.
B. It must be capable of toasting two slices of bread, at the same time, on both sides at once.
C. It must be what is commonly known as "a pop-up toaster."
D. It must toast bread for varying amounts of time.

Of course the ones they sell in the shops come in a wonderful array of shapes and colours (except they don't, being mostly some variant on white or silver, and some kind of rounded cuboid roughly the size of a small terrier dog). They do come in a wonderful array of prices however, from £3.94 to £166.39 ($6.10 to $259.33)—which is quite a price range for a single type of product in the same shop.

Guided by my (evidently misguided) belief that cheapness begets simplicity, I chose as my exemplar toaster the:

Argos Value Range 2-Slice White Toaster
Cat. # 421/9608 £3.94
—
Which includes:
- Coolwall
- Variable browning control
- Mid-cycle cancel
- Cord storage

—
A great value toaster, which embodies the centuries of incremental technological development, rising material wealth, and diverse global supply chains on which modern life depends. A must for any well-appointed kitchen!

It doesn't have a crumb tray, though.

Rule 2.
I must make all the parts of my toaster starting from scratch.

What does from scratch mean? From scratch means making something starting from the very beginning. What does starting from the very beginning mean? Starting from the very beginning means starting with nothing. Oh dear, my mind wanders…

I cycle to some remote woods with a deep lake, dismount my bicycle, and throw it in the lake. Then from my pocket I take a box of matches containing a single match, and a small bottle of petrol. I take off my shoes and all my clothes, pile them in a heap on the

ground, pour on the petrol, carefully light my single match, and . . . I'm naked in the woods and I'm making a toaster, *from scratch.* As anyone who's paid the slightest attention to Ray Mears's BBC series *Extreme Survival* knows, the first thing to do in a survival situation is find shelter and water. Then food. Once those essentials are sorted out, I can begin the long process of making clothes and the first tools that eventually will lead to the creation of my electric toaster.

But perhaps even this isn't enough—the apple pie recipe of noted astrophysicist and archetypal 1980s science documentary presenter Dr. Carl Sagan rings in my ears: "If you wish to make an apple pie from scratch, you must first invent the universe." The enormity of my task freezes me in my tracks.

Luckily, my naked contemplation of Dr. Sagan is interrupted by some startled ramblers, who report me to the local constabulary. I'm apprehended and receive a caution for breaching the peace and a small fine for contravening bylaws by starting a fire in a national park. They do, however, give me a lift in their police car back to the real world . . .

I'm making a toaster from scratch, and I live in London, in the United Kingdom, in the twenty-first century. I still want to sleep in my own bed, watch TV occasionally, and use the web to find stuff out, so I decide that from scratch means from the basic ingredients; that is, from the materials as they come out of the ground.

Rule 3.
I will make my toaster on a domestic scale.
I must make my toaster myself using tools that aren't fundamentally different from those that were around before the Industrial Revolution. This is because if I went and collected a bunch of ore from a mine, took it along the road to a smelting plant and had it smelted, then took the refined metal to a wire maker to have it made into wire . . . well, I wouldn't be making a toaster myself, would I? I'd be paying other people to use their very expensive and very complicated tools to make me a toaster. Besides, I don't have the money.

I want to make my toaster myself, on my own. This means I'm making an object that's usually produced in huge numbers in huge factories, singularly: a domestic object made on a domestic scale.

Thus, I decide:

A. Travelling overland is allowed because cars are just modern versions of horses. Flying is not allowed because human flight is a complete break from the past, with no pretechnological equivalent.
B. Using some domestic hand tools is allowed, even, say, an electric drill, because it just replicates a manual drill but is a lot quicker. Of course, using 3D-design software and a robotic milling machine is not.

So, with my rules logically infallible and set in stone I can begin.

* * *

The Royal School of Mines, Imperial College, London
Senior Common Room
Friday, 7 November 2008 (Lunchtime)

Professor Cilliers continues to ask his difficult questions…

PROFESSOR CILLIERS: When you look at what the old miners did, they smelted rock, but they started with a very high-grade ore. High-grade ore just doesn't exist anymore. You've got to understand that typical ores have half a percent copper in them. So say we want a kilogram of metal, we've got to treat a tonne of ore. Even for small-scale stuff you need quite a lot of rock. Can we find a lump of ore that has enough copper in it... there are mines that are rich in copper... if you go to Finland. The north of Finland. It'll take you a week. So you get the copper, and you plate it out into sheets and hammer it into the shape for the casing.

ME: The toaster I had in mind has a plastic casing.

And you need plastic for what?

To make it look like a toaster.

Well, I'm a metal man.

Well, the internal bits are metal.

The problem with plastic is that it's from oil. That technology is quite hard. That's why we didn't go through the Plastic Age before the Bronze Age, you know.

Right. I see.

If you look at those really groovy toasters, the handle comes out... um...

Dualit!

There we go, yeah. See, if you make a Dualit one, you need very little plastic. Lots of metal.

I sort of decided to model my toaster on a cheap one from Argos. They have a plastic casing, you see.

OK, so, you need a casing of some kind. Then you need an element.

Toaster elements I heard, or actually read, are made out of an alloy of chromium and nickel. And I looked around and I think there's a nickel mine in Siberia...

The nearest high-grade mine is probably in Turkey. But then you'll need a tonne, so... Anyway, then you need to get electricity to the element.

Copper wires.

And you need something to wrap the element around so it doesn't catch fire, basically.

I think in toasters they have some sort of mineral or something.

Yes, it's mica. Well it used to be, I don't know if they still use mica or some modern synthetic substitute now.

Steel

Steel

"If I can make steel," I tell myself, "then the project is a goer." I know that steel comes from iron. I have vague memories from school of terms like "pig iron," "blast furnace," and "slag."

Going by annual production figures (given in millions of tonnes per year), the steel in my Value toaster was most likely refined in China, from iron ore mined in Australia, Brazil, or possibly (but not certainly) China also. Unfortunately, I don't live in any of those places. The closest iron mine I can find to London is in the Forest of Dean, just on the English side of the border with South Wales. It's 139 miles away. Google says that I could walk there in forty-six hours if I didn't stop to eat or sleep. Luckily for me, some people had previously laid a railway line most of the way there.

I phone up the mine to arrange my visit. The man I speak to, Ray Wright, is rather nonplussed when I explain that I'm trying to make a toaster so would like

London to Clearwell Caves, 139 miles

to come and mine some iron ore. Quite surprisingly, he doesn't just hang up, but agrees to my visiting his mine the next day.

Iron for swords and ploughshares had been mined at Clearwell since the Iron Age. Up until it closed at the end of World War II, the mine had an output of thousands of tonnes a week. Ray had been a miner there when it was still going but now, along with his son Jonathan, runs Clearwell Caves and Ancient Iron Mine as a visitor attraction (voted Gloucestershire's Family Attraction of the Year for 2003).

Ray Wright, freeminer at Clearwell Caves and Ancient Iron Mine

We arrive at the mine in the late afternoon (we being me and my good friend Simon, whom I'd dragged along to help). It soon becomes clear, however, that when I'd spoken to Ray on the phone and asked if I could come and mine some iron ore "because I'm trying to make a toaster," Ray had thought I'd said, "because I'm trying to make a poster," and so had assumed I'd just want to take a photo or something. To be fair to Ray, the poster scenario does sound more plausible.

In any case, my notion of simply hacking a few bits of crumbly rock from the wall of a tunnel is quickly stripped away (I had, in fact, decided against bringing my pickaxe with me because I'd assumed one would be provided). As Ray makes clear, mining is not something to be taken lightly—pneumatic drills and perhaps explosives would be needed. It is also not a half-day activity, because simply to get to the working face of the mine requires a long ride in an underground train.

Crestfallen, I begin to think my journey was wasted, and I'll have to return to London with my suitcase still empty. After some embarrassingly persistent pleading on my part, Ray agrees to take us part way into the mine to see if we can find any ore lying about.

The walk through the mine is a fairly surreal experience because they have the Christmas decorations up. There's even a stuffed reindeer and one of Ray's assistants dressed as Father Christmas. I ask Ray what he thinks about the mine as a visitor attraction.

Ray is not a fan of the huge-scale mining operations seen in Australia and South America—the ones that made mining uneconomical on the scale possible at Clearwell. He is of the view that work on such a scale reduces humans to ants—no one understanding what their small part of the puzzle actually means. Or, as Karl Marx put it in his *Economic and Philosophic Manuscripts* (1844):

> He does not fulfill himself in his work but denies himself, has a feeling of misery rather than well-being, does not develop freely his mental and physical energies but is physically exhausted and mentally debased. The worker, therefore, feels himself at home only during his leisure time, whereas at work he feels homeless. His work is not voluntary but imposed, forced labour. It is not the satisfaction of a need, but only a means for satisfying other needs.

Ray still does some mining at his mine though, for grammes, rather than tonnes, of a substance called iron ochre. This is basically rusty iron powder, which is used as a pigment in lipstick and artists' oil paints.

I think Ray thought it a good idea to keep at least some mining going (even if just to make lipstick) so as not to end the history of mining that stretches back to a time when most residents of these islands lived in hovels (or indeed in the caves at Clearwell themselves). I wonder if

Ray feels there's something slightly ignominious about his mine having been turned into a tourist attraction.

What would have to change for the iron at Clearwell to be worth mining again? Probably nothing short of total global economic collapse. According to Ray, this is prophesied to happen in 2012 when the Mayan calendar runs out of numbers. I think he is holding out hope that Clearwell will become a working mine again sooner rather than later.

* * *

So, I didn't actually mine the iron ore myself; Ray did, some years previously. He took it from one of the displays at the end of the tour. I got it home, though, in a suitcase whose wheels quickly disintegrated, and it was heavy, forty kilograms heavy.

With the fraction of iron in the rock at about 40 percent according to Ray, and assuming I manage to extract, say, 50 percent of that, I should be left with eight thousand grammes of iron to play with. More than enough for my toaster. But first I have to somehow get the iron out.

This rock doesn't look anything like metal, it just looks like rock—maybe rock from Mars but still just rock. The task I face is to separate the atoms of iron from the atoms that make up the rest of the rock. Like getting blood out of a stone, but blood that is particularly iron rich.

Microscale iron ore transportation

The Imperial College library has a whole metallurgy section. Leafing through undergraduate textbooks on the subject, such as the classic *Principles of Extractive Metallurgy*, I realise that if you actually want to do extractive metallurgy, modern books on its principles are not what you need. Though well illustrated with flow charts explaining complex industrial processes and equations showing the reactions involved—all very useful if you're going to work at Tata Steel or somesuch—nowhere can I find a section on doing it yourself.

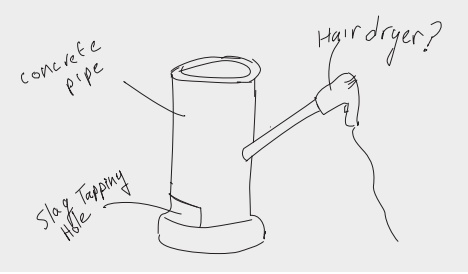
Imperial College library, metallurgy section

The Science Museum's history of science library is where I find *De re metallica*. It was written by Georgii Agricolae in the sixteenth century, in Latin, and translated by Herbert Clark Hoover and his wife, Lou, before he was elected thirty-first president of the United States. Dedicated to "the most illustrious and most mighty dukes" of Europe, it was the first book on metallurgy ever written—well, in the West at least (in China several books describing metallurgical techniques had already been published). It chronicles the diverse ways in which ores were mined and their metals extracted throughout the then-known world. Despite being written almost five hundred years ago,

Georgii Agricolae, *De re metallica* (1556), translated from the first Latin edition by Herbert Clark Hoover and Lou Henry Hoover, published by the *Mining Magazine* (London 1912)

it's actually more useful for my purposes than a modern textbook. It strikes me that a methodology from the sixteenth century is about the level of technology we can manage when we're working alone. In a sense, the smaller the scale on which you want to work, the farther back in history you need to go. Working on a domestic scale, as far as metallurgy is concerned, requires going back centuries.

The woodcut diagrams of the various "bloomery" furnaces are fantastic. Even the concept of a diagram itself seems to be under development: While labels are mostly confined to relevant objects such as a "set of bellows" or "crushed ore," as you'd expect, sometimes odd things like a "sleeping dog" or "some steps" or "peasants drinking mead" are labelled too. Of course, the materials I have on hand differ from those commonly available in the sixteenth century. Today it's much easier to get hold of cheap hair dryers than a set of bellows made of wood and leather. So that's what I use, hair dryers, along with an ornamental chimney pot from my mother's garden, a dustbin, some Vermiculite loose-fill loft insulation, half a door from a filing cabinet, a bit of tile, and some clay.

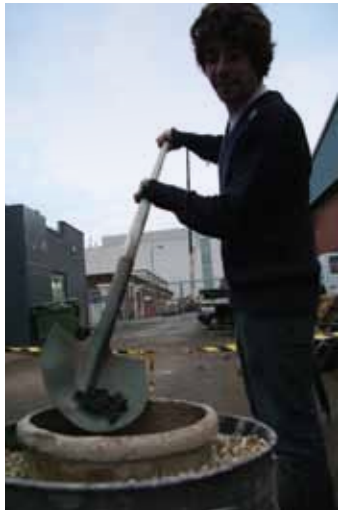


A primitive diagram of my modern, primitive furnace

Building the furnace

Crushing the ore

A leaf blower and electric temperature probe:
modern equivalents of a bellows and judgement borne of experience



Getting the fire going

Unfortunately, it turns out that the hair dryers have a safety cutoff to prevent them from getting dangerously hot, which they soon do. Luckily, I have an electric leaf blower on hand also.

There is no way of knowing whether the thing is actually working or not. All I can do is keep on feeding it with fuel and my smashed-up ore, and hope. My temperature probe catches fire about halfway through the process. Its last reading is 1206 degrees Celsius. This theoretically means the furnace is hot enough to be working.

* * *

Smelting iron late at night in a car park in central London

Tea time. Slightly acrid toast.
And so ended the first attempt at making steel.

I had been aiming to make what's called a "bloom" of iron—so called because it's meant to look like the bloom of a cabbage (to be honest, I wasn't even aware that cabbages had blooms). Late that night, after the last of the fuel had burned away, I poked through the furnace with a stick and pulled out a bobbly black mass of something heavy. Squinting through the fumes, and wanting to believe in success, I was convinced that what I had was indeed a bloom of iron.

Once my bloom was cool enough to handle, I tested it with a magnet. It was magnetic. With trepidation I brought it to my tongue to taste it—it tasted metallic! It perhaps didn't look shiny in the way we expect metals to be, but I reasoned that this must be what "old style" metal looks like—sort of "organic" metal. If it's (weakly) magnetic, tastes like metal, and looks (a bit) like metal, well, it must be metal! After actually bragging of my success for a few days (even demonstrating the magnetism of my incredible homemade metal to amazed friends and onlookers in several pubs), I finally got around to beginning to work a piece of my bloom into a toaster component. What really mattered about the metal I'd made was that it was malleable—that I could shape it into the bars for the grill and the flat sheets for the structure. Using a blowtorch, I heated it up until it glowed bright red, and hit it gently with a hammer. My "iron" shattered on impact, along with my dream of making a toaster.

I had failed the first hurdle. My project lay in ruins, as did my furnace. The faux-antique ornamental chimney pot I'd used for my furnace had literally melted itself with the heat and burst apart, and bits of the Vermiculite loft insulation I'd packed around it

had fused together. According to the blurb on the Vermiculite packet, this didn't happen below 1200 degrees Celsius. I'd got up to a hot enough temperature, but what had gone wrong?

With the benefit of hindsight, and a little more extensive research, I can see that my first, and quite fundamental, mistake was in my choice of fuel. In early furnaces, charcoal was used as a fuel. It was replaced by coke during the period we now call the Industrial Revolution, and coke is still what's used today. I had sort of assumed that because coke is used in modern furnaces, it must be generally superior as a fuel, and thus I decided to use coke (of which—perhaps not incidentally—I had a free and ready supply). However, coke had replaced charcoal not because it was better, but because trees for making charcoal were running out. Demand for iron had grown so much that basically the rate at which trees grow had become the limiting factor in the supply of charcoal, which limited the supply of iron. Because of the limited charcoal supply, there was therefore a lot of incentive for someone to work out how to use the abundant fossilised trees (coal), which could simply be dug up from the ground, rather than waiting for a load of new trees to grow.

The trouble was that even coke—coal that has been pre-roasted to remove impurities—still contains a lot of sulphur, phosphorous, and other impurities. Because the iron ore and fuel are mixed together and in direct contact in the furnace, the iron will absorb impurities from the fuel.

Due to these impurities, iron produced with coke is hard and brittle and not actually useful for making anything. It's known as pig iron, apparently not with

A bloom of iron... or not

reference to the much maligned hygiene habits of pigs, but because it was once common practice to pour the freshly smelted molten iron into a mould which resembled a sow suckling her piglets—a central feeder channel with smaller ingots coming off on either side. It seems rather an odd choice of visual metaphor to me, but when the term was coined, I suppose suckling pigs (and blooms of cabbages) would've been a rather more day-to-day sight.

To actually get useful material from pig iron involves a whole additional process to reduce the amounts of impurities. It's not a trivial thing to do, the various methods that were eventually developed led to the Industrial Revolution and the modern world. They all basically involve exposing molten pig iron to oxygen, to burn off the impurities that will burn (like phosphorous), or adding other elements to bind with the impurities that won't burn. Back when the method was first developed, the oxygen exposure came from stirring a puddle of molten iron in air; nowadays they use a water-cooled lance to inject pure oxygen into house-sized crucibles of molten iron, but the principles are the same.

Depending on how you remove the impurities, you can get three main flavours from your iron: cast iron, wrought iron, or steel. We're so used to thinking of materials as sharply distinct from one another, it's easy to forget that in the messiness of the real world pretty much everything is mixed together. Before chemistry enabled a theoretical definition of elemental iron, what "iron" was, what you could use it for, and how it could be made were incrementally eked out.

If you're going to be hitting your iron with a hammer, you need wrought iron, or maybe steel. It is possible to

make these without going through the intermediate step of making pig iron, if you have charcoal and the right knowledge and skill. I only had enthusiasm, which is a poor substitute when dealing with inanimate materials. At the time I wasn't aware of this fact of life, so I was hoping that the "bloom" I'd fished out of my furnace was at least wrought iron, or even that I'd got lucky and hit the carbon sweet spot and managed to produce steel.

My first mistake was caused by the wrong-headed assumption that a newer process was necessarily superior to an older one. Coke is only a better fuel than charcoal in a situation where trees are limited compared to the amount of iron and steel you need to make. Charcoal is better if the supply of trees is plentiful compared to the amount of iron you're making. Trying to make eight thousand grammes of iron definitely falls into the second situation.

Cleverly solving the tree shortage by working out how to use fossilised trees has led, hundreds of years later, to an atmosphere shortage. There are still plenty of fossilised trees left to burn; the problem is we want to burn so many that the atmosphere's ability to deal with all that carbon is being tested. Hopefully there's incentive enough (financial or otherwise) to cleverly negotiate this new shortage too.

My second wrong-headed assumption was that because iron smelting is an old technique, it must be pretty simple for a modern, educated guy like me to master. The iron in iron ore is present as iron oxide: iron atoms bound with oxygen atoms. Oxygen and iron have quite an affinity for bonding; iron oxide is also called rust and, as we all know, things rust without us having to do anything to them. So, to rip the oxygen

and iron apart requires a lot of energy, which is what you're supplying by taking your furnace up to 1200 degrees Celsius. But to help things along, you also need to supply something more attractive than iron for the oxygen to bond with, something "reducing," like carbon monoxide. Carbon monoxide can be made by incompletely oxidising things containing carbon—say, by burning fossilised trees with only a limited supply of oxygen. For example, if there's not enough air getting into a household boiler, there won't be enough oxygen for all the gas to grab two oxygen atoms each and form carbon dioxide—some of it will be left with one oxygen atom as carbon monoxide. If this happens in your household boiler, you could suffer from headaches, hallucinations (carbon monoxide poisoning has been implicated as the cause of many "haunted" houses), and, in tragic cases, death. In a furnace, however, carbon monoxide can help reduce the iron oxide to iron.

More air blowing through the furnace means more oxygen, the coke burning more completely and more fiercely, which means more heat. However, the coke burning more completely also means that less carbon monoxide is formed, which means the oxygen part of the iron oxide has less reason to leave the iron. So, not enough air and the furnace won't get hot enough, but too much air and, though it'll get hot, the atmosphere inside the furnace won't be right.

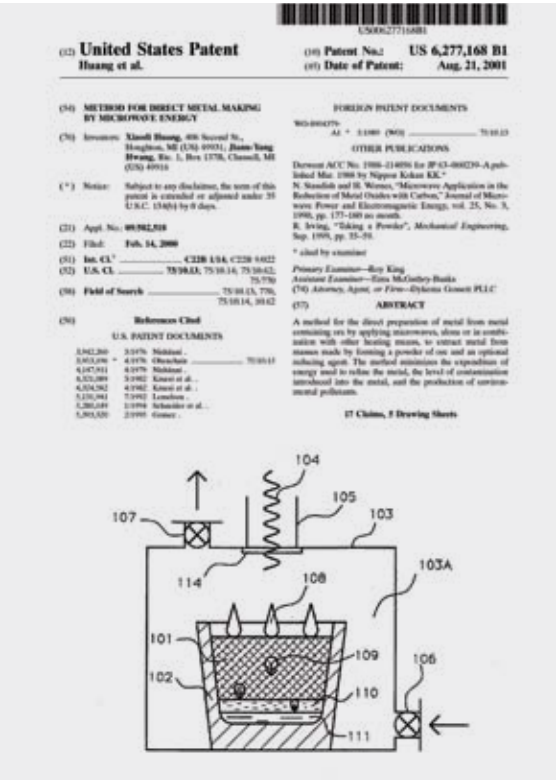
I'd had my leaf blower set at nearly full blast most of the time, but I had no way of judging if it was providing too much air, or too little. Furthermore, this balancing act means that there was no guarantee I'd judge it right if I attempted to smelt again. In fact, looking on the internet at other people's iron-smelting

attempts, I found that success was far from assured, with the majority of attempts failing to produce iron.

So, my "bloom" of "iron" could be a lump of pig iron with too many impurities in it because I'd used coke as a fuel instead of charcoal. Or maybe, if I'd had too much air going through my furnace, it could still be iron oxide. Or perhaps it could be some kind of mixed-up combination. In the first case I needed to melt it again in the presence of oxygen to try and burn off excess carbon and other impurities. In the second case I needed to re-smelt it but make sure the supply of oxygen was limited. In the third case, well, I had no idea. Each of the options required building another furnace, but with no guarantee that I'd manage to make it work the second time, or the third, fourth, or subsequent times after that.

After a few days of quite severe moping, I picked myself up, and in the long tradition of humans wishing to avoid hard work, started trying to think of ways out of my predicament. Ovens are more convenient than fires, and microwaves are more convenient than ovens. An oven goes up to only about 300 degrees Celsius, or "gas mark 9," but what about a microwave? It doesn't have a temperature gauge, but a time gauge. What would an hour in a microwave do to a piece of pig iron, or a piece of semi-refined iron ore? I find a patent online, granted in 2001 for the smelting of iron oxides using microwave energy. Detailed in the patent was the use of an industrial microwave. I didn't have access to one of those, but what about the kitchen microwave?

But hold on. I'd said in my rules that I wasn't going to use tools "fundamentally different" from those that existed in a pretechnological age.



(12) **United States Patent**
Huang et al.

(10) **Patent No.: US 6,277,168 B1**
(45) **Date of Patent: Aug. 21, 2001**

(54) **METHOD FOR DIRECT METAL MAKING BY MICROWAVE ENERGY**

(75) Inventors: **Xiaodi Huang**, 406 Second St., Houghton, MI (US) 49931; **Jiann-Yang Hwang**, Rte. 1, Box 1378, Chassell, MI (US) 49916

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/582,918**

(22) Filed: **Feb. 14, 2000**

(51) **Int. Cl.**[7] **C22B 1/14**; C22B 4/022

(52) **U.S. Cl.** **75/10.13**; 75/10.14; 75/10.62; 75/570

(58) **Field of Search** 75/10.13, 770; 75/10.14, 10.62

(56) **References Cited**

U.S. PATENT DOCUMENTS

FOREIGN PATENT DOCUMENTS

OTHER PUBLICATIONS

(57) **ABSTRACT**

17 Claims, 5 Drawing Sheets

Huang et al., United States Patent No.: US 6,277,168 B1 (2001)

Is a microwave anything more than a glorified fire? Is it fundamentally different?

Deep down I knew I thought it was. Microwaves heat things by spinning molecules rapidly back and forth with electromagnetic waves generated by a magnetron. Or so the saying goes. Fires cook stuff by transferring the energy released from oxidising carbon via electromagnetic waves and agitated molecules bumping into less agitated ones. To be honest, both methods of heating

sound equally exotic when described in the language of science. From a practical point of view, however, to make a fire I can just rub two sticks together.† To make a microwave, well, first I need some iron…

Oh, what the hell, this opportunity to taste the forbidden fruit of putting metal in a microwave is too good to pass up. Also, the patent authors claim that microwave smelting of iron produces only half the amount of harmful emissions as smelting using coke. I decide that it was a stupid rule anyway.

After some not-so-careful experimentation that necessitated replacing my mother's microwave, followed by some rather more careful experimentation, I manage to make a blob of iron about as big as a ten pence coin. A blob of iron that when hit with a hammer on a borrowed anvil doesn't shatter, but squishes as it should!

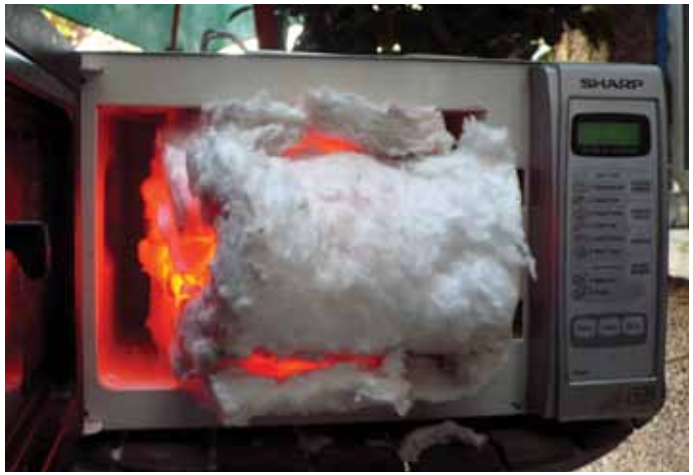
The recipe is as follows: Stuff the inside of the microwave with ceramic wool insulation, leaving a small cavity near the wave guide. Put a small piece of pig iron/half-smelted iron ore in a ceramic dish along with a bit of charcoal, cover, and place in the cavity. Cook on high for around twenty-five minutes. To produce enough iron for one toaster, repeat the process ad nauseam.

* * *

† I have since tried to start a fire by rubbing two sticks together. It is by no means an easy feat.

Insulating the crucible with ceramic wool to maximise the heat gained

An early failure



A success! The crucible glowing white hot in its partially unwrapped insulation

On the way home after my initial success that night, I'm rather overcome by the amount of highly pure metal casually lying around in the urban environment—the street lamps, the drain covers, the railings to discourage people from crossing the road in the wrong place—all massive hunks of steel or iron or something. There are tonnes of metal all around me, and I was overjoyed to have smelted a small piece to a purity that would be rejected by any manufacturer.

Securing the anvil against theft as it was too heavy to carry into the back garden

Testing my piece of microwave-smelted iron

Construction

Construction

Listening back to the recording of my first interview with Professor Cilliers, I'm slightly embarrassed at my naive optimism. "Yes, I'm going to make a steel spring to pop the toast up," and "Yep, I'm going to make all the electronics from scratch too… refining crude oil to make plastic? No problem, I'll just use a cooking pot." I can hear that while he didn't want to pour cold water on my ambition, he knew that the technical and scientific expertise assembled by countless people over centuries could not be replicated by me in the nine months that I had available.

That time is now up, and so I must take stock of the components that I've actually been able to make:

3 bits of iron internal toaster structure
4 iron grill bars
1 iron toast-raising lever
3 sheets of mica

1 top part of the plastic case
1 bottom part of the plastic case
1 top part of the plastic plug
1 bottom part of the plastic plug
1 short length of nickel-copper wire
3 copper pins for the electrical plug
3 copper wires for the electrical cord

Twenty-two parts. My toaster doesn't have a spring to pop up the toast when it's done, or an adjustable timer mechanism, or a cancel button. And it's questionable whether it's actually capable of toasting bread. At the time of writing, I've not plugged it into an electrical outlet, out of respect for the health and safety officer at the Royal College of Art and, if I'm honest, because I'm mildly scared of electrocuting myself or, worse, someone else.

I have plugged it into two twelve-volt batteries wired in series to make twenty-four volts, and the element does get hot. Too hot to touch, in fact (I have a burn on my finger to prove it). But my element doesn't glow red—possibly because the batteries provide ten times less power than the United Kingdom mains electrical supply. This means that, to a pedant, what I've made could at the moment be classified as a bread warmer rather than a bread toaster. I'm still hopeful that I'll see some toast when I up the voltage, or use white bread instead of the whole wheat I've tried so far.

Toast. Has that really been my goal for the last nine months? In one way, yes. But in another more accurate way, no.

I wanted to get under the skin of the slick-looking objects that surround us, but don't really come from

anywhere (unless you work in supply chain management). To the average consumer (like me) a toaster begins its life on display in a shop, waiting for you or someone to buy it. To pay £3.94 for a toaster that's "from a shop" seems vaguely reasonable, but £3.94 for a toaster that is entirely made from stuff that a few months ago was rocks and sludge distributed in giant holes all over the world, then brought together in an elaborate series of processes and exchanges, gradually assembled by many people, wrapped, and boxed and then somehow shipped to that shop, which is heated and lit and has people being paid to assist you in your purchase: Somehow £3.94 for all of this doesn't seem to quite add up.

My attempt at making a toaster myself, from scratch, has been wildly, absurdly, outrageously "inefficient." My toaster cost 250 times more than the one from Argos, and that's just the money I spent on it directly (mostly travelling to mines). If I'd included all the food I ate, and the shoes I wore out, and so on, then its final price would be more. Much more. And its carbon footprint must be huge, at least a size 14 (European size 48).

And thus the miracle of modern capitalism is brought starkly into focus. As Jonathan Ive, senior vice president of industrial design at Apple Inc., said to me (well, me and the rest of the audience), "A complex product being made is like one of those films of a glass smashing that they play backwards—all the bits come together in the right place at exactly the right time to be assembled into this thing—it's amazing." I agree with Mr. Ive; it is amazing. I even have one of his iPhones, which at the moment I quite like (though

strangely it does make me feel like a bit of an idiot when everyone else in the room has one too—like going to a party and everyone's wearing the same "fashionable" top—but that's the point of fashion right?).

However, before we get too chummy with Adam Smith and his invisible hand, it seems that the need to buy more stuff to stimulate our economy, and the need to consume less to save our environment, are on a collision course. So while the £1187.54 price of my toaster doesn't really include all that it cost to make it, £3.94 isn't really what the Argos Value version cost either.

The real "cost" of products is hidden. We don't see (or smell) the pollution emitted when iron is smelted or plastics are made. You wouldn't want it happening in your back garden (though my neighbours have been quite nice about it). Equally we don't have to live with all the stuff we throw "away" (my neighbours I feel sure would complain about a personal garden rubbish dump, especially come the summer). But pollution and rubbish don't just disappear, they end up somewhere, and if not dealt with properly, are costing someone something (their health perhaps). At the moment there's lots of stuff not included in the price of the Value toaster—"externalities" that aren't included in the money economy.

For example, say the copper in the Value toaster was open-cast mined by copper miners in Chile. As we know, large holes in the ground tend to fill with water, which leaches out minerals from the exposed rocks, as happened at Rio Tinto and Parys Mountain. This water, acidified and contaminated with a whole load of heavy metals, such as arsenic, usually finds its way into the nearest river.

At the moment, no one "owns" the river, so the copper miners don't have to pay for stinking it up, and we all get cheap copper for our toasters. Except, of course, someone's paying a cost—like the people living along the river, or relying on it for water. We get the benefit of cheaper copper, but don't have to pay the costs—the costs are external (to us, anyway). However, if *I* owned that river, you can be damn sure that I'd demand a hefty sum from anyone who wanted to turn it into a blood-red home exclusively for acid-loving bacteria. Perhaps it would be so hefty that it wouldn't even be worth mining near my river. Or perhaps the copper miners could haggle me down by agreeing to certain conditions (like being extra careful to not stink up the river). They could then pass this slightly less hefty sum onto the wire manufacturers, who'd pass it onto the toaster manufacturers, who'd then undoubtedly pass it onto me and you—and, to be quite honest, fair enough.

But now imagine the river as the atmosphere, and the whole world's industry as the copper miners. I can imagine myself hypothetically owning a river, but even at my most delusional I can't see myself owning the entire atmosphere of planet Earth. So no one (not even hypothetically) owns the atmosphere, and industry, ourselves, cows, squirrels, etc., are all free to use the atmosphere as they wish, to add a bit of carbon dioxide, methane, sulphur dioxide, and so forth. If no one has to pay anyone to use the atmosphere, then there's no cost associated with polluting it. Environmental regulations are an attempt to impose a cost, but groups with different interests argue for different costs. The Emissions Trading System implemented by the

European Union is an attempt to let the free market in part determine the costs of polluting, but it has run into huge difficulties. In any case, it only applies in Europe.

If all the costs associated with their production were captured, well, toasters would cost a bit more, and perhaps we wouldn't buy and discard them so often, and of course not so many people would be able to afford them…

Here I am, yapping away about how things should be more expensive (well, technically that things *would* be more expensive if we were paying the right price for them). It seems a bit pious to be claiming that I want to pay more for stuff. Well, worse actually, it's hypocritical. Like lots of people, I generally buy the best stuff (that interests me) and that I can afford and probably go on just about as many holidays as I can afford, too (usually on the cheapest flights I can find).

I'm a willing beneficiary of the cheapness of things. When I go to buy my next computer (I'm interested in computers), I'll certainly be looking at the prices of all the different choices very carefully and will buy the fastest, newest one I can get at the best price I can find. I can say this with some certainty, because that's what I did the last time I bought a computer, and the time before that. My present computer is supposedly much better than my first computer, for all sorts of reasons, but the thing is, I don't feel *that* much better off—many of my friends *still* have better computers than me.

We compare what we have with what other people have. Poverty, then, is relative—that's not to say it isn't a very bad/uncomfortable/life-shortening/fatal position to be in, just that it's not an absolute. What it means to

be "poor" changes through time and across the world—as does what it means to be "rich," "well off," or merely "comfortable" (though what it means to be "starving" is flatly invariable). In terms of toasters, if everyone else has a toaster and I don't, well, I'll feel a bit deprived, and I'll go and buy a toaster if I can afford it. The fact that wealth is relative is, I think, one thing that drives the economy. It's not that people have "infinite wants" (as economists traditionally claim), just that no one wants to be at the poor end of the scale.

So, to expect people to stop wanting things when other people have more than them (and sometimes a lot more), because of costs that are difficult to even conceptualise, is I think a bit unrealistic. It's not that people are selfish and nasty—just that we're all constrained by lots of things, especially by what the people we're in contact with are doing, or have. It's a lot easier to give up smoking if the people you tend to smoke with are giving it up too (so far, so good anyway). People's attitudes to modern life won't *suddenly* change because of the (generally) slow and undramatic progression of climate change and environmental degradation—especially if the perspective they see "modern life" from is that of someone who's not currently living it. Developing countries are developing; what happens when every household in China can enjoy a toaster bought for only a few yuan? As a Chinese fashion designer told me while we were in wealthy and minimalist Stockholm, "Here, less is more. In China, more is more."

The collision of the economy with the environment is happening now… if it were a film of a car crash in slow motion, then I guess the front bumpers would be crumpling and bits of glass would be flying up as the

headlights smash. So how can we make the collision more of a glancing blow as opposed to a chaotic and bloody head-on pileup?

There's a whole battery of ways to make this come about—economic means like landfill taxes, giving pollutants the monetary cost they deserve, more and better consumer information. The answers, I think, already exist (lots of people, many of them more clever than I, have given it much thought), they just need to be implemented. Of course the implementation is the tricky part, especially if legislation is required, and legislation is where the big changes can be made. Differing legislative environments are why the same company can operate both the world's dirtiest nickel smelter in Siberia and one of the cleanest in Finland. We're just in need of politicians with the gumption to act.

Recently I heard this quote from the American environmentalist David Brower: "Politicians are like weather vanes. Our job is to make the wind blow." I'm not sure whose job he means specifically, but I think the analogy of culture as wind is a good one. And the direction the cultural wind blows is shaped by economics, fashion, science, literature, beliefs, technology, stories, news, events… all mixed up together. Right. So does that make it pretty much everyone's job to help keep the cultural winds blowing in the right direction? But many of us already have jobs, and don't want a second one if we can help it. Maybe more of a pastime then?

My attempt to make a toaster has shown me just how reliant we all are on everyone else in the world. Though there's romance in that idea of self-sufficiency and living off the land, there's also absurdity. There is no turning

back the clock to simpler times—not without mass starvation anyway. Besides, the majority of the world is still trying to turn the clock forward.

It also has brought into sharp focus the amount of history, struggle, thought, energy, and material that go into even something as mundane as an electric toaster. Even if we still don't have to directly pay what it costs, we can at least value it for what it's worth. Looking beyond just toasters, this means making sure the stuff we need to buy lasts longer, and investing as much ingenuity and money taking things apart as we do putting them together. My trip to Axion's polymer recycling factory was informative on this score. Perhaps there should be two instruction books with every product: one detailing how to set the product up and use it, and another detailing how to take the thing apart and separate it into the different components or materials from which it's made, ready to be fed back into other products without degrading the quality of the material. Is it unrealistic to imagine "the consumer" taking apart and sorting everything that they throw away? At the moment it seems completely so—who would spend an evening dismantling their old toaster or television? The health and safety issues would also be difficult. ("Step 1: Unplug your appliance. Dismantling your toaster while it's still connected to the power supply could be hazardous!")

But there's not much point in imagining futures that are the same as the present. For one, it's not very interesting, but it's also not very useful, and can be dangerous. For example, lots of banks made lots of loans because they assumed the future was going to be basically the same as the present, and look where it

got them (and us). The extent of the kind of change needed to avoid a nasty maiming collision can be summarised by many different statistics, one of which is that 60 percent or more of ecosystem "services" are being degraded or used unsustainably (ecosystem "services" are those important things we get from the environment—like fresh water, clean air, soil in which to grow things, and so on). Other statistics are available. The point is, big changes are needed, and big changes happen. Whether we end up dismantling our old TVs, or paying someone else whatever makes it worth their while to do it for us, doesn't really matter—what matters is that getting rid of stuff you no longer want has to become worth doing properly.

I've had rather a nice time visiting places as well as making my toaster. It's certainly something that I'll never throw away, because (to put it cornily) it embodies so many memories: walking the highlands of Scotland, clambering through the shafts of Parys Mountain in Wales, the Santa's grotto at Clearwell Caves. Companies spend a lot of money trying to invest their brands with emotion and meaning. For me, the stuff that really has emotion and meaning attached to it is stuff with a bit of history. The provenance of things is important. Maybe when we're in school each of us should assemble our own toaster, our own kettle, our own little microwave or something, then perhaps we'd be more likely to keep these things for longer, and repair and look after them. This would mean these products would be more than things that just come "from the shops."

The toaster without its casing

My toaster


Toasters
£16.45
£11187.54
£24.45
£22.95
Let us lighten your load
Breville
cream 2 slice toaster
Breville
cream 2 slice toaster