The Toaster Project

The Toaster Project

OR A HEROIC ATTEMPT TO BUILD A SIMPLE ELECTRIC APPLIANCE FROM SCRATCH

Thomas Thwaites

PRINCETON ARCHITECTURAL PRESS · NEW YORK

Left to his own devices he couldn't build a toaster. He could just about make a sandwich and that was it.

—Douglas Adams, *Mostly Harmless* (1992)

For Merle, Bette, Vito & Felix

Published by
Princeton Architectural Press
37 East 7th Street, New York, NY 10003

For a free catalog of books call 1-800-722-6657
Visit our website at www.papress.com

© 2011 Thomas Thwaites
All rights reserved
Printed and bound in China
14 13 12 11 4 3 2 1 First edition

No part of this book may be used or reproduced in any
manner without written permission from the publisher,
except in the context of reviews.

Every reasonable attempt has been made to identify
owners of copyright. Errors or omissions will be corrected
in subsequent editions.

Editor: Sara Bader
Designer: Paul Wagner

Special thanks to: Bree Anne Apperley, Nicola Bednarek Brower,
Janet Behning, Fannie Bushin, Megan Carey, Becca Casbon,
Carina Cha, Tom Cho, Penny (Yuen Pik) Chu, Russell Fernandez,
Jan Haux, Linda Lee, John Myers, Katharine Myers, Margaret Rogalski,
Dan Simon, Andrew Stepanian, Jennifer Thompson, Joseph Weston,
and Deb Wood of Princeton Architectural Press
—Kevin C. Lippert, publisher

Library of Congress Cataloging-in-Publication Data
Thwaites, Thomas, 1980–
The toaster project, or A heroic attempt to build a simple electric
appliance from scratch / Thomas Thwaites. — 1st ed.
p. cm.
Includes bibliographical references.
ISBN 978-1-56898-997-6 (alk. paper)
1. Thwaites, Thomas, 1980—Themes, motives. 2. Manufactures—
Miscellanea. I. Title. II. Title: Heroic attempt to build a simple electric
appliance from scratch.
NK1447.6.T49A35 2011
683'.83—dc22
2011006094

Foreword by David Crowley

Where do the products that fill our lives come from? "China" is, of course, the standard answer to this question. The "dragon economy's" mammoth factories are high in our consciousness, drawing the attention of environmentalists worried about the effects of breakneck industrialisation and Western politicians troubled about competition.

But "China" is an inadequate answer. Where do our things really come from? What lies behind the smooth buttons on your mobile phone or the elegant running shoes on your feet? What is involved in extracting and processing the materials that give themselves up from the earth so reluctantly? Where does the copper in your "Made in China" kettle come from? Were the electronic components and integrated circuits in your TV remote control assembled by machine or by hand? And what exactly has been integrated in that circuit anyway?

We rarely ask these kinds of questions. Perhaps the nature of our consumer culture makes us averse to them. Consumer goods play a clever game of "hide and show" with us: they call our attention, promising to satisfy our wants. Yet, at the same time, they veil their origins. Appearing to have no history or past, they materialise on the shelves of our shops as if by magic. This is what Walter Benjamin described as the "phantasmagoria" of commodity culture. Modern societies, it seems, not only forget the material and practical origins of the commodities they consume, they seem to have elevated them to minor deities.

In *The Toaster Project* Thomas Thwaites set himself the task of making one of the most commonplace consumer goods from scratch. This meant not assembling this modest appliance from other existing components but extracting and processing the materials from which the parts of a toaster are made. This book records his major failures and minor triumphs.

Thwaites begins his mission by dismantling the cheapest toaster on sale in the shops. This is an exercise in reverse engineering, the dark art practiced by military engineers trying to learn enemy secrets and copyright lawyers attempting to track down patent infringements. Thwaites's project rapidly becomes another kind of reverse engineering. Acting alone and eschewing the armoury of techniques available to modern industry, he finds himself in the position of late-medieval man with a limited repertoire of skills and expertise. His most effective guide to the task of smelting iron from ore is, for instance, not the latest issue of *International Journal of Material Sciences* but *De re metallica*, a sixteenth-century treatise.

Modern myths of omnipotence come to seem like hubris when Thwaites is defeated by the task of smelting metals, something first practiced eight thousand years ago. We know more now, don't we? We are more expert than our ancestors, aren't we? Yet, at the same time, we are also reliant on the knowledge they produced. This is pointed out by the philosopher Michel Serres, in *Conversations on Science, Culture, and Time* (1995), when he asks us to consider a new car:

> It is a disparate aggregate of scientific and technical solutions dating from different periods. One can date it component by component: this part was invented at the turn of the century, another, ten years ago, and Carnot's cycle is almost two hundred years old. Not to mention that the wheel dates back to neolithic times. The ensemble is only contemporary by assemblage, by its design, its finish, sometimes only by the slickness of the advertising surrounding it.

Submerged in our toasters are layers of hard-won and deeply practical knowledge—if only we could tap it.

In the spirit of many recent endeavours to limit the techno euphoria of twenty-first-century modernity, Thwaites set some sharp restrictions on his project. Famously, Lars von Trier and Thomas Vinterberg called for filmmakers to return to first principles in their "Vow of Chastity." The obligation to shoot on-site with actors, using natural sound and handheld cameras, would, they argued, ensure a cinematic purity that has been lost in the age of CGI (computer-generated imagery) and lowbrow cinema. Thwaites's particular holy "vows" seem simple—"I must make all the parts of my toaster from

scratch" and "I must make my toaster myself"—but like most rules, they require interpretation. Making a toaster "on his own" means not employing other people, but in the world today, can anyone ever really be entirely independent, forgoing the expertise and services of others? Surely that's the lonely territory of antimodern hermits like Theodore Kaczynski, author of another vow of chastity, "The Unabomber Manifesto." *The Toaster Project*—over time—becomes a social one: in the course of his quest, Thwaites makes willing conscripts of professors, press officers, and even amiable drunks.

In one regard, Thwaites's *Toaster Project* seems closer in spirit to von Trier's *Five Obstructions* (2003) than the "Vow of Chastity." In this documentary the Danish filmmaker set his friend and mentor, Jørgen Leth, the task of filmmaking under five impossible conditions. Failure was guaranteed, but what made the project worthwhile was Leth's resourcefulness and imagination (as well as his attempts to stretch the rules). Making a toaster from scratch is surely an impossible task, but not a pointless one. Thwaites's project reveals much about the organisation of the modern world, not least the extent to which Britain's industrial capacity has been dismantled. The country's mines, foundries, and factories have become, it seems, another form of phantasmagoria.

Preface

Hello, my name is Thomas Thwaites, and I have made a toaster.

It took nine months, involved travelling nineteen hundred miles to some of the most remote places in the United Kingdom, and cost me £1187.54 ($1837.36). This is clearly rather a lot of time, effort, and money expended for just an electric toaster, but when I say, "I have made a toaster," I mean really *made* it, literally from the ground up; starting by digging up the raw materials and ending with an object that Argos sells for only £3.94 ($6.10).

Actually, this is just a version of the truth. An alternative version would be that I tried and failed to make a toaster. That's not to say I haven't got a rather odd-looking appliance that kind of toasts bread sitting on my kitchen worktop, which cost £1187.54 and caused me to travel around the United Kingdom for nine months. No, what I mean is that although I set

Argos Spring/Summer 2009 catalog

out to make my toaster completely from scratch, I realised along the way that there can be no such thing as "from scratch."

As I sit writing this in a café in London, everything I can see, except maybe some woolen clothes and some wooden furniture, began life as a collection of rocks and sludge, buried in different parts of the world. It's not that this café has a geological theme or something, it's that the rocks and sludge have been transformed in some extremely clever ways, becoming this laptop, or the tasteful wood-effect plastic flooring, or that electric toaster.

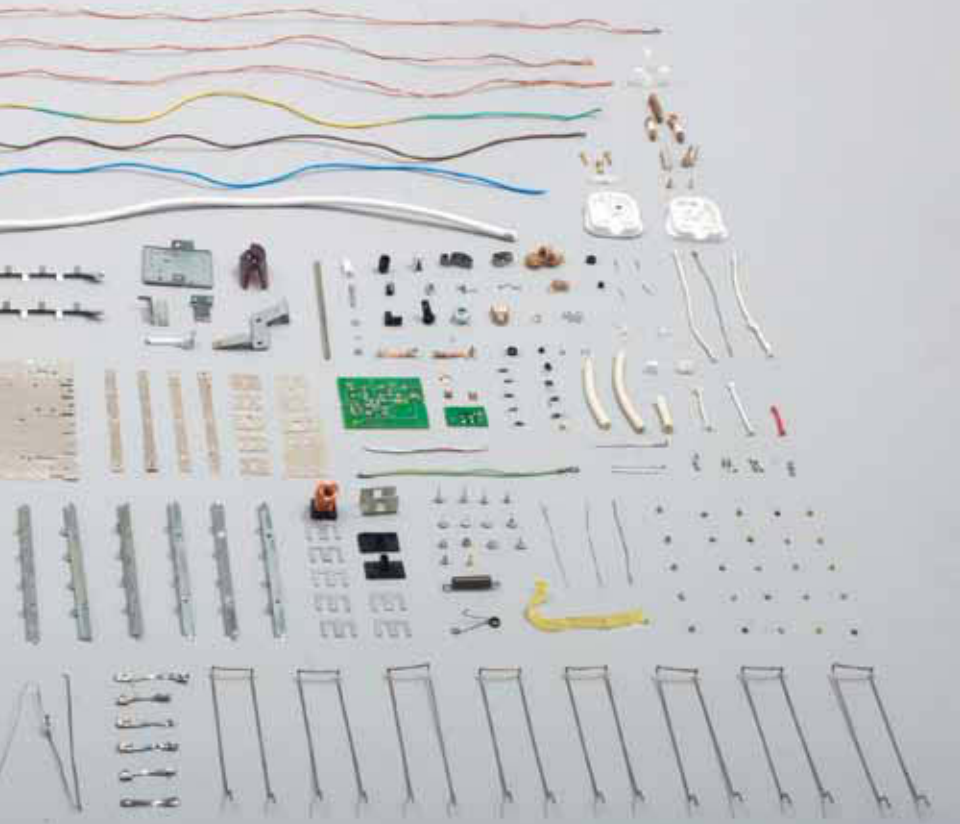
How the hell do some rocks become a toaster?

This fundamental question motivated my, let's face it, faintly ridiculous quest to make one from scratch. But I also wanted to explore the grand-scale processes hidden behind the smooth plastic casings of mundane everyday objects, and to connect these things with the ground they're made from. I'm interested in the economies of scale in modern industry, the incremental progression of science and technology, and exploring the ever-widening gulf between general knowledge and the specialisms that make the modern world possible. The point at which it stopped being possible for us to make the things that surround us is long past. Well, that's what it feels like, but is it?

My toaster took me on a journey not only around the United Kingdom, but on a trip through civilisation's history as well, from the Bronze Age to today.

The following pages are the story of that journey, and that toaster.

Deconstruction



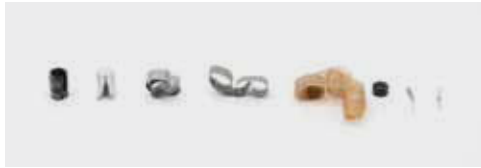
Deconstruction

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.

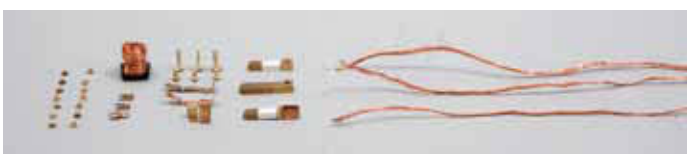
To start with, the element: the hot passion within every toaster. No element = no heat = no toast. After some research I discover that for most toasters, the element is made of nickel-chromium resistance wire, sold under the brand name Nichrome. Nichrome is used because it has a high electrical resistance, 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 l 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.

* * *